NATURE

Vol. 143 SATURDAY, JANUARY 14, 1939 No. 3611

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Editorial and Publishing Offices:
MACMILLAN & CO., LTD., ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831 Telegraphic Address: Phusis, Lesquare, London
The annual subscription rates are: £2 12 0 British Isles, £2 17 0 Foreign, payable in advance

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PHUSIS, LESQUARE, LONDON

Telephone Number :
WHITEHALL 8831

Vol. 143 SATURDAY, JANUARY 14, 1939 No. 3611

Intellectual Co-operation between the Nations

WE live and move and have our being in a world of contradictions—in a world which has shrunk in its dimensions to an almost incredible extent during the last generation. America and the Antipodes are but a few days' journey from Europe; wireless can put a girdle round the globe in a time undreamt of by Puck; the concerted labours of the physicist, the engineer, and the biologist have made it possible to transport perishable produce on a large scale from country to country—produce which adds in a high degree to the amenities of life in our community. All these results have been achieved by thought and labour which were truly international in character.

The fundamental problems of life, of art and of ordered knowledge know neither racial nor geographical boundaries. Grant that we have reached a certain stage in our gropings into the infinite, then, within those limits, the message of Plato and of Confucius, of Dante and of Wordsworth, of Beethoven and of Brahms, of Newton and of Einstein, are for all ages and all climes. Unless man is free in thought, and free in the expression of his thoughts, the wisdom of the past and of the present is of small avail for the increase of the happiness of the human race; and it is a bitter comment on the trend of our modern civilization that men should be turning to the noble words of the Areopagitica as expressing beliefs still to be fought for, not as truths for ever demonstrated by the struggles and aspirations of centuries past and gone.

"As good almost kill a man as kill a good book; who kills a man kills a reasonable creature, God's image; but he who destroys a good book, kills reason itself, kills the image of God, as it were, in the eye. . . . We should be wary, therefore, what persecution we raise against the living labours of public men, how we spill that seasoned life of man, preserved and stored up in books; since we see a kind of homicide may be thus committed, sometimes a martyrdom; and if it extend to the whole impression, a kind of massacre, whereof the execution ends not in the slaying of an elemental life, but strikes at the ethereal and fifth essence, the breath of reason itself; slays an immortality rather than a life." How would these immortal words have struck our ears in the freer air of a generation ago? How do they read to-day?

We have said that we live in a world of contradictions, for, though the gifts of science have brought the nations closer in space and in time than ever before in the history of civilization, yet, paradoxically enough, man stultifies the effects of these benefits in countless ways. He erects economic barriers between the nations; he exacerbates national disagreements, visualizing the exchange of commodities, on which our mutual prosperity depends, as a process of warfare; he produces want and misery in a world which, wisely ordered, could go far in using the gifts which scientific advance is providing, to supply the material needs of all.

All the more reason, then, to welcome any national pronouncement which emphasizes the spirit of co-operation rather than that of cut-throat competition, and such a pronouncement is doubly welcome when it is concerned with the fostering of general cultural relations between a great democracy and the other countries of the

world. The order recently signed by Mr. Cordell Hull, the Secretary of State in President Roosevelt's Government, establishing in the Department of State a Division of Cultural Relations, is of great significance. In a civilization where knowledge is increasing, where values are changing, at a rate never before dreamt of, and in which almost every possible element of instability is present, no opportunity should be lost for bringing together nationals of all countries to discuss, amicably and fraternally, problems which are the concern of all, and few better meeting grounds could be chosen than those which are provided for the encouragement and strengthening of cultural relations. Individual attempts to institute such contacts have been many and have been attended with varying degrees of success, or failure, but Governments are slow to take such action, and Mr. Cordell Hull's order marks an important step in advance, and provides an example that may well be followed by other Governments as a most weighty means of diminishing the tensions, and alleviating those differences which, unhappily, are such a prominent feature in international relations to-day. The order, which takes effect as from July 1938, has scarcely, as yet, received the notice which its importance merits. The significant part of the text, as published in the issue of *Science* of November 25, 1938, runs :

> For the purpose of encouraging and strengthening cultural relations and intellectual co-operation between the United States and other countries, it is hereby ordered that there shall be established in the Department of State a Division of Cultural Relations.
>
> The division will have general charge of official international activities of this department with respect to cultural relations, embracing the exchange of professors, teachers and students ; co-operation in the field of music, art, literature and other intellectual and cultural attainments ; the formulation and distribution of libraries of representative works of the United States and suitable translations thereof ; the preparations for and management of the participation by this government in international expositions in this field ; supervision of participation by this government in international radio broadcasts ; encouragement of a closer relationship between unofficial organizations of this and of foreign governments engaged in cultural and intellectual activities, and, generally, the dissemination abroad of the representative intellectual and cultural works of the United States and the improvement and broadening of the scope of our cultural relations with other countries.
>
> In fulfilling its functions, the Division of Cultural Relations will direct the conduct of exhaustive studies and have responsibility for the elaboration and the carrying into effect of a comprehensive and co-ordinated plan of activity in this country for the strengthening of international intellectual and cultural relations ; it will assist in the preparation and interpretation of treaties in this field ; it will supervise the formulation of regulations and procedure necessary for the fulfilment of obligations under the Convention for the Promotion of Inter-American Cultural Relations and other treaties and conventions relating to cultural relations to which the United States may become a party ; it will draft or review correspondence with foreign governments, American diplomatic and consular officers and all other correspondence pertaining to these activities ; it will collaborate with the Office of Education and other government departments and agencies, the National Committee on Inter-American Intellectual Co-operation, other educational and cultural organizations and institutions and foreign missions in Washington.
>
> The Division of Cultural Relations will function under the general supervision of the Under Secretary of State and in close co-operation with the geographical divisions.

It will be noted that science receives no overt mention, but it is to be presumed that scientific advances and the implications of such advances will receive full consideration under some of the more general heads of the order.

Official action in democratic communities is apt to follow, rather than to lead public opinion, save in exceptional instances, but Mr. Cordell Hull's order synchronizes with other movements which have already been discussed in the columns of NATURE. The British and American Associations for the Advancement of Science, in their arrangements for an exchange, in alternate years, of lecturers to deliver at the meetings of the Associations addresses which shall, broadly speaking, be conceived on the lines of presidential addresses, have initiated a movement which will undoubtedly have far-reaching effects ; and this movement is further assisted by the decision of the Associations to keep officials of each Association intimately acquainted with the details of the proceedings of their respective bodies. It is good to know that the Government of the United States of America regards these decisions as having sufficient importance to warrant their forming part of a wider national policy, and such recognition inspires the hope that other countries will participate in this movement for the encouragement of international cultural relations.

The structure of our civilization is cracking ; if it is to be saved at all—and, imperfect though it may be, it *is* worth conserving and developing—it can only be saved by the encouragement of those movements which stress the urgent need for international co-operation and understanding.

The Colonial Service in the British Empire

The Colonial Empire and its Civil Service
By Charles Jeffries. Pp. xxv + 259. (Cambridge: At the University Press, 1938.) 10*s.* 6*d.* net.

THIS book, as explained by Lord Harlech in his introduction, is an "attempt to tell, as straightforwardly and simply as possible, the story of the development of the British Colonial service". The author has had a difficult task, but has succeeded admirably in condensing into the pages of a comparatively small volume an immense amount of matter that concerns the Colonial Service.

His Majesty's Colonial Service of a hundred years ago dealt with regions that are now no longer under its control. In these days, the great Dominions have their own separate form of administration and although the island Colonies, such as those in the West Indies and Mauritius, and the West African Colonies of Sierra Leone and the Gambia do indeed appear on the old list, others such as Malaya, Nigeria, the Gold Coast and the East African territories were not then parts of the Empire. The chapter on the early history of the Service indeed affords fascinating reading and gives one a clear idea of the way in which the Colonial Empire has grown and how many changes have had to be made to meet its expanding needs. One cannot help feeling that in those early days the territories which now form the Colonial Empire were the Cinderellas to what are now the Dominions. These were larger and more vociferous in their demands and had developed far more rapidly than the smaller Colonies.

Matters have changed since the Dominion Office was formed in 1925, and we read of the remarkable way in which the Colonial Service proper has been strengthened and re-organized since the Great War. The time was evidently ripe, for a perusal of these pages enables one to realize in what a haphazard, not to say casual, manner the Colonial Empire of Great Britain has grown up. The laws and regulations even now differ in a remarkable way between territories often adjacent, and it was presumably to counter the parochial attitude that was (and still is) so often exhibited by individual Colonies that the wide reforms of the post-War period were instituted. The Great War had indeed brought to light many glaring defects in our organization, more particularly perhaps in the failure to develop fully the natural resources of the Colonies, and the public health and education of the natives. As an example of the new outlook, one may instance the reports of the Lovat Committee in 1927 and 1928, which made recommendations on agricultural research and administration in the non-self-governing Dependencies and also suggested the institution of one service for all the Colonies. Its proposals, after implementation, have done much to develop the agricultural, forestry and other technical services.

The Warren Fisher Committee followed with further recommendations, and this led to the decision of the Secretary of State to form a unified Colonial Service in 1930. Subsequent developments recognized the existence of a single Imperial Colonial Service. Within this, branch services have been organized on a professional and not on a regional basis. Thus we now have Colonial administrative, legal, medical, agricultural services, and so on, each having a technical adviser in the Colonial Office itself. A further step was to lay down that members of these unified services would normally be recruited from outside the Colony itself. This, as is explained, "left room for the fullest scope to be allowed to each Colony to develop its public service in the best way suited to its local conditions". There is little doubt that the unification of the service has done much to increase the prestige and sense of *esprit de corps* among its members, a point that has been ably brought out by the author. The clarification of the proposals regarding recruitment has also had the effect of attracting a number of desirable recruits from the universities.

Difficulties in the strict application of these ideals naturally occur, since the Colonies differ from each other in so many ways. Disappointment may be felt when the Colonial Office feels it expedient to give way to a local Government in the matter of filling some post locally instead of by an appointment from the unified Colonial Service. These difficulties are always likely to crop up from time to time in communities that are in the process of developing a political self-consciousness. Again, much remains to be done in levelling up the anomalies that undoubtedly exist between various Colonies in respect of salaries, housing, leave passages, and so on. This matter needs urgent attention, as unless it is equitably settled one suspects that certain Colonies will acquire a reputation that will render them unpopular to the serving officer and this will lead to an inevitable deterioration in the standard of work.

The subdivision of the unified Colonial Service into separate technical services has many points in its favour. It is to be hoped, however, that these

sub-services will not become too water-tight. The closest co-operation between all officers is needed to solve many of the pressing problems, and indeed their solution is almost always a matter of team-work. The higher posts in the Service should be open to every member, whether he be a specialist or an administrative officer, for it is ability and personality that count, and the wider the net is spread the more likely is the right man to be found.

The book is to be commended to all who are in any way interested in colonial questions, as it gives a complete history of the Colonial Service from its very early days to the present time.

G. E.

The Mechanism of the Egg

Embryonic Development and Induction

By Prof. Hans Spemann. (Yale University: Mrs. Hepsa Ely Silliman Memorial Lectures.) Pp. xii+401. (New Haven: Yale University Press; London: Oxford University Press, 1938.) 22*s*. 6*d*. net.

AT last we have the pleasure of welcoming the largest work so far written by one who is perhaps the greatest living master of experimental morphology. It has received admirable treatment by the Yale University Press; the clear printing aids the reader's eye, and the matt paper does justice to every nerve-cell in the numerous illustrations.

It was Gustav Born who long ago discovered the remarkable healing power of amphibian embryos, and the manner in which they can be operated upon with very fine glass needles, hair-loops, and other delicate instruments. Under the dissecting microscope the tissues cut cleanly "like a mixture of cheese and cotton-wool" and the methods permit, of course, of that fundamental requirement of experimental morphology, namely, the transplantation of pieces or regions of one embryo into another, that is, into an abnormal but living environment. It may then be seen whether they follow their previous course of development, or whether they fall into step, as it were, with their new environment, and go along with it to whatever its destiny may be in the finished embryo.

Born did not carry the experiments far. It was Hans Spemann who, in a "Gedankengang" extending over thirty years, analysed, with various collaborators, the process of determination in the amphibian embryo. With Hilde Mangold in 1924 he discovered the primary organization-centre (organizer), in the dorsal lip of the blastopore, which determines the main axis of the vertebrate embryo, that is to say, the neural tube, notochord and somites.

The present book, after a short historical discussion of some of the ideas current in earlier days of embryology, begins with a detailed account, not of this 'primary organizer' just now mentioned, but of the 'secondary organizer' which works on the ectoderm to produce the lens of the eye, when the eye-cup grows out towards the skin from the forward end of the nerve-tube. At first sight, this way of introducing the subject of organizer phenomena may seem to have more disadvantages than benefits, for the processes of lens-induction vary a good deal as between different species of amphibia. Yet this very fact allows of a special insight into the relation of stimulus and response in organizer action. In some amphibia, the skin is absolutely incapable of producing a lens without the stimulus from the eye-cup, but in others it produces a more or less good lens if the eye-cup stimulus is not allowed to act. Hence the concept of 'double assurance' derived from engineering. If one mechanism should fail in the normal course of development, another appears in reserve. It is not yet clear, however, whether the second process only comes into play if the first is inhibited, or whether both processes work together in the same direction in normal development as a "kombinative Einheitsleistung". In any event the question does not arise so acutely with regard to the primary organizer.

The next series of chapters is devoted to the state of affairs in the gastrula during the working of the primary organizer. Spemann deals in turn with tests of potencies, inductions of secondary (twin) embryos by normal organizers and by abnormal media, such as dead tissues of adult organisms, or by chemical preparations. Although his account of the morphological problems has all the brilliance which we expected, the same can scarcely be said of those sections dealing with the biochemical aspects of the phenomena. It is a striking exercise in the psychology of science to observe how his assured touch deserts him when he appraises chemical evidence and chemical arguments. Thus he does not appreciate the importance of Holtfreter's discovery that on heat-coagulation (or other protein denaturation), tissues such as ventral ectoderm, which do not normally possess inductive power, acquire it, although he himself says (p. 232) that the "substance is then either produced anew, or *set free* by suitable treatment" (italics mine).

He does not see that the ventral ectoderm, in which the substance may be set free, is precisely the same thing as the presumptive epidermis, on which organizer activity has perforce to be tested. He does not therefore distinguish between implants which do injury to the tissue and so liberate the tissue's own organizer-substance, and those which act in minute concentrations, and are hence less likely to liberate it. He thus gives up too easily the search for logical consistency in the chemical facts, and takes refuge in a facile writing off of the whole effect as probably "unspecific".

What puzzles the reader most, however, is the kind of assumption which Spemann regards as self-evident. Thus on pp. 220 and 370, where he is discussing the induction of eyes and lenses after implantation of adult heart, he says, "One thing is evident from the beginning, that a cooked heart, for instance, which induced an isolated lens, cannot have brought about this effect by some specific lens-forming agency". Now the evidence that the primary organizer involves a chemical substance is accepted by everyone. Since all adult tissues act, the simplest assumption is that they all contain the substance, capacity to react to it having long been lost. If they contain the primary organizer, why not various secondary organizers? There is at any rate no lack of chemical compounds present in cells for which no function has yet been found. So why is it self-evident that heart tissue cannot contain secondary lens-organizer substance?

There are two places where the characteristics of the morphologist's outlook appear with special force. Thus on p. 242 Spemann says, "The altered metabolism in the dorsal lip of the blastopore is, surely at first, a consequence of the induction, not its cause". This is strikingly reminiscent of Liebig's view which called forth from Traube in the early days of the study of yeast fermentation the famous remark: "Der Chemie vermag wohl die physiologische Tatsachen, aber nicht der Physiologie die chemische, erklären". Or again, on p. 245, Spemann asks how "structure can be produced by a factor which, like a chemical substance, lacks structure in itself, in the morphological sense of the word?" Surely the whole of organic chemistry is, in a real sense of the word, a realm of structure. With molecules of the complexity of proteins, we need surely have no excessive intellectual difficulty in picturing a relation between morphological differences and chemical differences, even though as yet we have no detailed knowledge of the manner in which this occurs. On the other hand, no book could show better than this one the beauty of the analysis of biological phenomena which can be accomplished by the morphological mind. Around p. 354, for example, the results of exposing the ectoderm of different species to the action of the same organizer is discussed. The ectoderm reacts, but it gives the answer, as it were, in its own language. Stimulated to form a balancer, it does so, but it makes one like embryos of its own species, and not like that of its host. Stimulated to form mouth parts, it forms teeth or horny jaws as the case may be, irrespective of which of these formations is characteristic of its host. The 'cue', says Spemann, therefore, is rather vague; the ectoderm reacts, but in its own way, according to the tradition of its species.

In later chapters, Spemann considers the gradient theory of Child from a critical point of view. Some may feel that he displays an almost too excessive aversion from gradients. We may grant that the claim of Child to show that gradients are gradients of respiratory rate has never been substantiated. But not a few writers have found the concept of gradient useful, and indeed if the diffusion of a chemical substance takes place from a point in space, as may well happen in the case of the primary organizer, a gradient system must be formed. Even a differential supply of nutrient substances in the ovary as a factor in polarity is objected to (p. 325). The fundamental trouble is stated on p. 331: "It is hard to understand how qualitative differences may arise from quantitative ones in different regions". That depends on one's philosophy. There *are* philosophers who have found the transformation of quantity into quality a fundamental property of Nature, observable in many fields besides embryology, as in the classical instance of the increasing length of the paraffin chain.

In the conclusion, Spemann justifiably says that the more exact our knowledge becomes about the chemical substances involved, the more the burden of explanation is thrown back on the reactivity, the competence, of the tissues affected by them (p. 369). He even writes, "the very conception of the organiser became problematical". It is to be hoped that this will not cause misunderstanding. The facts of organizer action have been demonstrated again and again. Organizer phenomena involve the action of 'morphogenetic hormones', and their importance is that for the first time they bring home to us how closely bound up normal morphogenesis is with normal embryonic metabolism.

This is a great book. But it is not a book to be read uncritically. The best way in which we can render homage to one who is perhaps the last great representative of that "reine deutsche Wissenschaft—Entwicklungsmechanik", is to read and re-read him, framing new hypotheses, which may or may not be better than his, for his perdurable facts.

JOSEPH NEEDHAM.

History of Cambridgeshire

The Victoria History of the County of Cambridgeshire and the Isle of Ely
Edited by L. F. Salzman. (The Victoria History of the Counties of England.) (Published for the University of London Institute of Historical Research.) Vol. 1. Pp. xiii + 436 + 21 plates. (London: Oxford University Press, 1938.) 63*s*. net.

IT may seem a matter for surprise that Cambridgeshire, a county in which is a great centre of learning, should have had to wait so long for the first volume of its Victoria History. The delay is the reader's gain. Most of the chapters in this volume, but more especially those dealing with geology—at least as regards the quaternary deposits—botany, and archæology could not have been written a generation ago, when publication of the County Histories began, as they appear here. This is not entirely a matter of fresh evidence, though this plays its part; but new methods of investigation and interpretation have remoulded the reconstruction of prehistory, while a new orientation has broadened, and at the same time intensified, the study of the environmental conditions and culture of early man. For this we are largely indebted to the geographico-archæological studies of the Cambridge region by Sir Cyril Fox in the period immediately following the Great War, and the later studies of the Fenland Research Committee, to which the investigation of the formation of the peats of the Fenland has contributed not a little.

The first volume of the Cambridgeshire series follows the general plan of the History as a whole. It deals with the natural conditions, the geology, botany, and zoology of the county, and with the evidence of human occupation in prehistoric and Saxon times, ending with the Domesday record. In the last named the county is peculiarly fortunate in the survival of three independent records of the land tenures of the period.

Although the geological structure of the county is simple, being divided between Jurassic and Cretaceous, the surface, although nowhere greatly elevated, is sufficiently varied. The feature which gives the county its special interest is the fenland and its influence on the fauna and flora. Although the fenland has been drained, Wicken Fen survives for the study of former conditions; but as is shown by the chapter on botany by Dr. H. Godwin and those dealing with the zoology under its several divisions, many rare and interesting species have vanished. Among these are the avocet and the ruff as breeding species and the great bustard; while the county was probably the last haunt of the large copper butterfly and, it may be, the polecat. The oldest specimen of the *P. daplidice* butterfly, now in the Oxford entomological collection, was caught here in the last decade of the seventeenth century; and the swallow-tail, *P. machaon*, rare in Britain, still survives.

Cambridgeshire, however, is in a marked degree a marginal area; and it is noticeable how in the discussion of numerous questions a crucial piece of evidence is drawn from areas at varying distances outside the county border. This point especially is to be noted in connexion with the quaternary deposits and their relation to the history of early man, here considered in the revised studies of the late Dr. J. E. Marr, which show the county as marginal to the great East Anglian area, while in the later periods Dr. Clark's analysis of culture indicates how it bears a like relation, now to the south and south-west, now to the cultural spread, which can, as a rule, be traced to the Wash.

In the chapter on early man, for which Dr. J. G. D. Clark is responsible, the palæolithic period is represented by the records of a number of finds, extending from the Chellean to the close of the period; but on the whole the showing is poor. This, as the author indicates, is due to a lack of systematic investigation, rather than proof positive that palæolithic man did not spread to this area from the East Anglian region. In the earlier chapter on geology, it pointed out that Cambridgeshire offers a poor field for observation, owing to the closing down of the industrial undertakings upon which the geologist has to rely for his opportunities; and the same applies to observations of the earliest periods of prehistory, when funds are not available for specific investigations. Incidentally, it may be pointed out that in both the Iron Age and in the Saxon period, with which Mr. T. C. Lethbridge deals, much valuable information was undoubtedly lost through the development of the sites at the St. John's cricket ground, Grange Road, and at Girton in the eighties of the last century, when archæological knowledge and method were immature.

From mesolithic times onward, much evidence has come from research within the county area, and is still accruing, which is of great value in the study of the character, succession, and chronology of prehistoric cultures. For this, as already mentioned, thanks are due to the Fenland Research Committee, for which Dr. J. G. D. Clark himself

has to no small extent been responsible. The application of the methods of pollen analysis to the peat deposits, it is true, has not as yet produced the results which were anticipated; nevertheless, the investigations at Plantation and Peacock's farms, Shippea Hill, to which frequent reference is made here, have provided an illuminating and unique sequence from Tardenoisian to Early Bronze Age, and demonstrated their relation to the marine deposits laid down when this area was at a lower level in relation to the sea.

The chapter by Dr. Clark on early man and that on the Anglo-Saxon period by Mr. Lethbridge raise numerous points, which invite discussion. Not the least interesting of these is the question of the continuity of the population in the successive phases of the Bronze Age, the thickly populated Romano-British period, and Saxon times. If these and other matters have to be passed over, it is for lack of space, rather than of inclination. Cambridgeshire, so far, has indeed been fortunate in its county historians.

Comparative Study of the Lower Plants

Vergleichende Morphologie der niederen Pflanzen:
eine Einführung in deren Formbildung und Formwechsel auf entwicklungsgeschichtlicher Grundlage. Von Prof. Dr. Bruno Schussnig. Teil 1: Formbildung. Pp. viii + 382. (Berlin: Gebrüder Borntraeger, 1938.) 36 gold marks.

THE appreciable advances in our knowledge of lower plants during the present century has led to the publication, especially on the Continent, of a large number of relevant works, but most of these deal with Algæ or Fungi only as the case may be. A comparative treatment of the lower plants is therefore to be welcomed, and there can be no doubt that Prof. Schussnig has produced a book that will take its place among the accredited works on Thallophyta. This first volume is divided into four sections, two dealing with the cell and cell-division and two with the organization of the multicellular thallus. Here also is included a consideration of structure in relation to physiological function which is as unconvincing as most earlier accounts dealing with this topic.

It is natural that in a book of this scope new points of view should be advanced. Schussnig propounds the hypothesis that all parenchymatous types of thalli (for example, the polystichous Ectocarpales of Oltmanns) represent condensed systems of branching filaments, either uni- or multi-axial. This interpretation is extended not only to the parenchymatous Ectocarpales and Bangiales, but also to the Laminariales, Fucales, and even Dictyotales. Such a view has long been accepted for the Florideæ, but the facts provided by the author in support of its application to the parenchymatous Phæophyceæ carry little conviction. It is not feasible to discuss this theory here, the more since additional evidence is to be furnished in the second volume. Schussnig also reaffirms (p. 180) his view that the Conjugales are derived from a polyenergid ancestry, and a similar origin is suggested for the Red Algæ, but it cannot be said that any strong evidence is adduced.

With the very wide range of topics discussed, it is perhaps inevitable that the treatment should in places be somewhat one-sided; for example, the problematic cytology of the Blue-Green Algæ would seem to have merited a fuller discussion than is afforded it on p. 33, where really only Baumgärtel's point of view is considered.

The treatment of the Fungi is not as full as that of the Algæ, a fact which is particularly noticeable in the very brief consideration of the plectenchyma of the former and in the discussion of parasitism. There are diverse minor points that call for criticism. As examples, we may note the reference to the spireme as a normal stage in mitosis (p. 18) without mention of the fact that many recent authorities regard it as typical only of meiosis, the homology of the pseudocilia of Tetrasporaceæ with flagella (p. 59) for which there appears to be no adequate evidence, the use of the term cœnobium as synonymous with colony (p. 190), and the statement that growth-rings occur in the medulla of Laminariales (p. 375). The reference to Juller, rather than to Klebs or Pascher on p. 216 is misleading.

Despite such criticisms, however, Schussnig's book is often suggestive and stimulating, and the comparative treatment of many topics, especially in the first two sections, of great value. The book is essentially one for a specialist, since the matter is treated in such a way as to render it accessible only to those with considerable previous knowledge. It would, moreover, have fulfilled a more useful purpose had the text not been encumbered by the introduction of many new terms. The illustration is ample and excellent.

F. E. FRITSCH.

Farm and Garden Seeds

By Prof. S. P. Mercer. With a Section on the Seeds Act, 1920, by A. W. Munro. (Agricultural and Horticultural Handbooks.) Pp. 205+14 plates. (London: Crosby Lockwood and Son, Ltd., 1938.) 10*s*. 6*d*. net.

PROF. MERCER has produced an interesting and readable book on farm and garden seeds. While it may not make an appeal to a very wide public, it should find a place in the libraries of those for whom the author, in his preface, states he has attempted to cater; namely, the agricultural student, those concerned in the business of seed testing, and such others as are interested in how things grow and the methods adopted to ensure that the seeds they buy are what they purport to be and may reasonably be expected to germinate.

The book consists of five chapters, together with one appendix giving physical data about crop seeds and a second giving notes on practical seed testing. The first four chapters are by Prof. Mercer. After a short and somewhat condensed chapter on the formation, structure and growth of a seed, he goes on to give an interesting account of commercial seed production in Great Britain and indicates the sources of supply for other commercial seeds which are drawn from other countries. The chapter on seed testing bears the authoritative imprint of one who has for a number of years been in charge of an official seed-testing station. Prof. Mercer's final chapter contains a short description of each of the main crop and weeds seeds with the most beautiful and delicate illustrations of the seeds which the reviewer has ever seen. These illustrations are the author's own drawings and he is to be congratulated on them.

The final chapter in this book is contributed by Mr. Munro, of the Ministry of Agriculture, who, from intimate personal knowledge, gives an account of the provisions and administration of the Seeds Act of 1920.

An index, sufficiently comprehensive to make reference easy and quick, is included. R. R.

Biology for Pharmaceutical Students and Others

By Prof. S. Mangham and A. R. Hockley. Pp. viii+613. (London: Baillière, Tindall and Cox, 1938.) 21*s*.

LIKE many other introductory biology books recently published, this is a comprehensive, though elementary, survey of the subject; but it is difficult to believe that the authors were sufficiently alive to the needs of those for whom the book was specifically written, namely, students preparing for the preliminary scientific examination of the Pharmaceutical Society of Great Britain. The price, and also the length, are too great for a student's book, particularly in view of the fact that it is supposed to be of a preliminary nature; no doubt the latter determined the former. One explanation of the undue length is that the authors have borne in mind the students' later needs in pharmacognosy and physiology; but to forestall this later teaching in the student's first year is doubtful policy. In fact, it does not seem feasible to expect preliminary students to assimilate profitably all that this book offers at the beginning of their professional studies.

Furthermore, especially in those parts dealing with plant physiology, there are too many names—usually surnames only—of research workers. These, too, in places seem to crop up indiscriminately. For example, in the two pages dealing with vitamins, apart from that of Hopkins, the names of Howard and Hirst only are mentioned. The account would be better balanced if these had been omitted. Again, in the section on the mechanism of photosynthesis, the first paragraph alone contains six names of workers from Priestley to Boussingault. These can mean little to a visitor to the subject. They will make little impression on his mind and can only be a useless burden to the student, for whom the volume is written.

The book contains numerous excellent illustrations.

The Flight of Birds

By C. Horton-Smith. Pp. 182+17 plates. (London: H. F. and G. Witherby, Ltd., 1938.) 7*s*. 6*d*. net.

THIS book is a short popular account of bird flight. Some of its readers will be primarily interested in birds, others in aeronautics; it is perhaps inevitable that a few should be disappointed. The author is at his best when describing those attributes of the bird's wing which he has obviously studied at first-hand; he is not quite so convincing when translating the behaviour of the wing into aeronautical language. It is impossible at present to make any useful comparison between the air flow past a bird's wing during active flapping flight and that past a simple aerofoil, and it is therefore much to be regretted that Dr. Horton Smith does not always make it quite clear whether his statements apply to the wing of a bird or the 'wing' of an aeroplane.

Some of Dr. Horton-Smith's views may possibly be open to criticism on aerodynamical grounds, but as a biologist he has performed an extremely useful task in bringing into this small volume a large number of important observations which can scarcely fail to stimulate an interest in the subject.

Mineralogie von Bolivien

Von Friedrich Ahlfeld und Jorge Muñoz Reyes. Pp. vii+89+1 plate. (Berlin: Gebrüder Borntraeger, 1938.) 10.50 gold marks.

SINCE David Forbes in 1865 wrote his account of his researches in the mining districts of South America, many other British mineralogists have taken an interest in the rich mineral localities of Bolivia and the many rare species found there. A German translation of the Spanish "Mineralogia Boliviana" by Ahlfeld and Muñoz Reyes will be very welcome. In this book descriptions are given of 171 mineral species with brief mention of the places and modes of occurrence. Some of the occurrences recorded are new. There is a good index of localities, and the book is illustrated by crystal drawings and a frontispiece.

Nature of the Cyclol Bond

By Dr. Irving Langmuir, For. Mem. R.S., and Dr. Dorothy Wrinch

I

THE confirmation by X-ray data[1,2] of C_2, the 288-residue cage structure proposed for the insulin molecule[3], makes it of interest to consider the nature of the cyclol bond, upon the postulation of which this structure and the cyclol theory of protein structure in general[4] depend. The making and breaking of a cyclol bond between an NH group of a polypeptide chain and a CO group of the same or of another polypeptide chain requires only the migration of an H atom thus:

$$\rangle NH + OC\langle \rightleftharpoons \rangle N—(HO)C\langle .$$

The making and breaking of a cyclol bond is therefore a prototropic tautomerism, inter- or intra-molecular, which indicates a special type of binding of the H atom. (A recent investigation has shown that a similar situation actually exists in crystalline diketopiperazine[5]). As a prototropic tautomerism, it is to be sharply contrasted with the making and breaking of a peptide link which, requiring the intervention of another molecule, say water, may be written:

$$—NH—OC— + H_2O \rightleftharpoons —NH_2 + HOOC—.$$

In order to direct attention to the fundamental difference between a prototropic tautomerism on one hand and a hydrolysis (or alcoholysis, etc.) on the other, it is convenient to talk in future of cyclol *bonds* and peptide *links*.

In current usage, the term protein is applied to anything having the chemical composition of amino acid condensation products. One class stands out as of paramount importance for the understanding of living matter, namely the crystalline globular proteins such as trypsin, pepsin and so on. These substances are already well defined in a number of ways, and it is with proteins belonging to this category that the cyclol theory is concerned.

Among the properties by which the substances are already characterized are the following:

(1) They have definite molecular weights which are discretely arranged.

(2) They contain certain numbers of various particular amino acid residues and these numbers are frequently powers of 2 and 3.

(3) They are soluble in water or salt solutions, but their solubility is affected by changes in *p*H.

(4) They denature under very slight stimulus.

(5) They spontaneously form monolayers of extreme insolubility.

(6) They exhibit a high degree of specificity in biological reactions.

It has already been shown that the cyclol hypothesis explains (1), (2), (4). With regard to (3) and (5), we may point out that the extreme insolubility of the monolayer formed from a soluble protein[6,7,8] indicates that the globular protein has a structure in which hydrophobic groups can be completely masked, so leading directly to the idea of a cage structure which presented itself in the cyclol theory as a deduction from the geometry of polypeptide chains. The

Fig. 1.

CYCLOL-6 (IN CENTRE) WITH ITS TRIAZINE RING DOTTED. THE OPENING OF THIS RING YIELDS EITHER THREE DIKETOPIPERAZINE MOLECULES (SHOWN ON LEFT) OR A CLOSED POLYPEPTIDE CHAIN OF SIX RESIDUES (SHOWN ON RIGHT).

lacunæ in the fabric allow ionized (and other) *R* groups to modify their positions profoundly in response to changes in *p*H, and indeed to lie inside or outside the cage. The spontaneous formation of protein monolayers from globular proteins in solution indicates that weak bonds only are broken. This we interpret to mean that, in the formation of monolayers, some or all of the cyclol bonds are opened, few or none of the peptide links being broken, so that protein monolayers consist of polypeptide chains partially or wholly decyclized, for the most part without open ends, the hydrophobic groups forming a separate phase in the surface. This type of structure explains many of their striking characteristics: for example viscosity, elasticity, etc.[7,8].

It may be emphasized that the breaking of cyclol bonds yields different degradation products according to the path of fragmentation. Thus cyclol-6 yields three diketopiperazine molecules or a single 6-residue chain (Fig. 1). In standard circumstances, a preferential path of fragmentation, probably largely determined by the *R*-groups,

is to be expected[9], and it may be presumed that one and the same structure will under standard conditions break down in a unique way. Further, if preferential paths of breaking cyclol bonds be postulated, preferential paths of making cyclol bonds must also be postulated. Experiments have recently been reported purporting to disprove the cyclol hypothesis, in which glycyl leucine and leucyl glycine dipeptides were mixed and glycyl glycine and leucyl leucine dipeptides were not formed[10]. Even if triazine rings were formed (and of this no evidence was offered), there seems no reason to suppose that the structure will break down to yield anything except the original molecules. We are therefore unable to accept these experiments as evidence against the cyclol hypothesis.

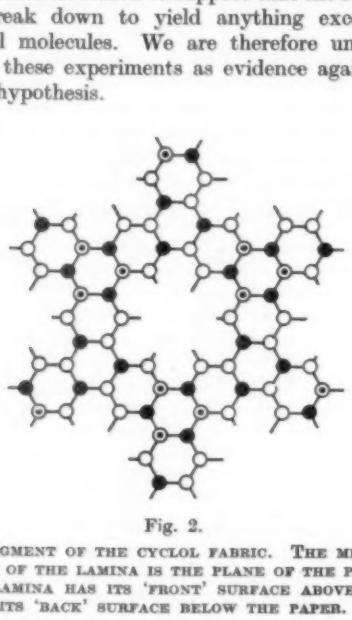

Fig. 2.

A FRAGMENT OF THE CYCLOL FABRIC. THE MEDIAN PLANE OF THE LAMINA IS THE PLANE OF THE PAPER. THE LAMINA HAS ITS 'FRONT' SURFACE ABOVE AND ITS 'BACK' SURFACE BELOW THE PAPER.

● = N.
○ = C(OH), HYDROXYL UPWARDS.
⊙ = C(OH), HYDROXYL DOWNWARDS.
○— = CHR, DIRECTION OF SIDE CHAIN INITIALLY OUTWARDS.
○- = CHR, DIRECTION OF SIDE CHAIN INITIALLY UPWARDS.

These suggestions of preferred paths of fragmentation apply equally to the globular proteins characterized, on the present view, by a specific set of amino acid residues, in a definite spatial interrelationship. They imply that for each protein there are one or more points at which the breaking of cyclol bonds normally starts. Thus an insulin molecule forming a monolayer would form a specific set of wholly (or partially) decyclized polypeptide chains. In this way, we can explain the highly characteristic films formed by different proteins, which permit an unknown protein to be recognized instantly as insulin or pepsin or papain and so on[6,7,8].

II

From the point of view of biology, cytology and immuno-chemistry, however, the most striking characteristic of the globular protein is its high degree of specificity. This, we suggest, indicates an organized structure with its own characteristic modes of vibration, which depend on the nature and arrangement of the various constituent amino acids. Since the breaking and making of cyclol bonds is a prototropic tautomerism, we anticipate that in appropriate circumstances there may be a kind of resonance in the molecule which accounts for the stability of the cyclol fabrics and the cyclol polyhedra. The cyclol fabric, a fragment of which is shown in Fig. 2, contains no double bonds and thus Frank[11] believed that "the cyclol molecule in itself offers no chance of constructing a resonant system". But each triazine hexagon has three parallel hydroxyls on the three carbon atoms, the next triazine hexagons in the fabric having their three hydroxyls on the other side of the fabric. With a symmetrical structure of this kind, it seems highly probable that the protons, instead of being attached to individual oxygen atoms, lie between the oxygen atoms serving as hydrogen bonds between them. There may thus be a marked resonance involving the three oxygens and the three hydrogens. Furthermore, resonance on a larger scale between neighbouring triazine groups may also be expected.

This suggestion of intramolecular hydrogen bonds in the cyclol fabric is in line with the intramolecular bonds already postulated in a wide variety of compounds, including ice, alum, natrolite and other zeolites, oxalic acid dihydrate and formic acid, in which oxygen atoms are shown, by crystal structure data, to lie abnormally close together[12]. Such a close distance of approach is evidence of considerable mutual energy of oxygen atoms, which can only be due to the presence of hydrogen between them[13]. For certain compounds, for example, salicylaldehyde and *o*-nitrophenol, the presence of intramolecular hydrogen bonds has been confirmed spectroscopically by the non-appearance of the hydroxyl band[13]. In these cases the oxygen-oxygen distance is about 2·5A., considerably shorter than the distance of 2·7A., that represents double the radius of the ion O^{--} and very much shorter than that for neutral oxygen. In the case of the cyclol fabric, hydroxyls are carried by three carbons in a triazine ring, which lie at the distance apart of $\frac{2}{3}a\sqrt{6}$, which is equal to 2·45A. if a, a length intermediate between the C-C and C-N distances is taken (as has so far been done) as 1·5A.

One of the most extraordinary properties of proteins is their specificity in biological reactions.

The hæmoglobin in each different type of animal seems to differ in spectrum and in details of its behaviour with oxygen. We are thus forced to conclude that, in proteins, certain features of the molecule can transmit some effect to other parts of the molecule, particularly to prosthetic groups. Such transmission of chemical influence, although observable to some extent in such compounds as sterols, seems to exist in a unique degree in the proteins: in long-chain compounds, on the other hand, there is practically no evidence of such transmissions to distances of more than a few atoms. It is well known that in aromatic chemistry the resonance, for example in the benzene molecule, causes substituents in different parts of the molecule to have an effect on one another very different from what would be expected if no resonance occurred. The high specificity of the proteins therefore in itself seems to demand resonance to a degree greater than that in other known chemical compounds. It would seem that the cyclol polyhedral structure with its sets of rings within rings and its multiple paths of linkage between atoms (cf. Fig. 2) should be capable of just such a type of resonance.

May we not perhaps regard each diazine ring in the cyclol fabric as the analogue of an electrical resonant circuit, the natural frequency of which is determined by the character of the side chains in this ring? Then n resonant circuits coupled together would be characterized by n^2 frequencies, no one of which being exactly what it would be if the resonant units were separated from one another. An electrical network, the resonant circuits of which have the geometry of the cyclol polyhedra, would give very close coupling between the adjacent hexagonal units. Thus the structure as a whole should possess a wide range of frequencies. The situation is somewhat analogous to that in the Debye theory where a crystal has a large number of modes of vibration. So in the protein the cyclol structure may be characterized by a whole spectrum of frequencies definitely correlated with the symmetry of the structure as a whole. Thus if a single factor disturbs the symmetry, it might have a profound effect upon some of the characteristic frequencies. If we imagine that these frequencies are important in the interactions between proteins and in funnelling the energy to certain parts of the molecule, we have a possible reason for the important effects produced by apparently minor changes in the structure of the protein molecule.

III

It appears that a strong case can be made out for the cyclol theory, since its implications, derived by simple geometrical arguments, fits the facts summarized above. The theory depends upon one postulate which thus becomes of special interest, particularly as its formulation has occasioned some uneasiness in chemical circles. The question then arises as to the possibility of proving directly the existence or non-existence of cyclol bonds.

The work on protein monolayers indicates that only weak forces are required to open cyclol bonds. We are of the opinion that many chemical techniques are sufficient to rip open the cyclol fabric into polypeptide chains, so that the chemist by his very operations may destroy the structure he seeks to study. On this view, any apparent contradiction between the cyclol hypothesis (which regards the globular proteins as polypeptide fabrics) and the chemical data relating to proteins (which appear to show them to be polypeptide chains) disappears. The situation is thus reminiscent of that in quantum physics, where the conditions required for the observation of the position and velocity of an electron themselves modify the phenomena under study. Similarly, it has recently been suggested[14] that enzyme studies do not permit the deduction that cyclol bonds do or do not exist in globular proteins. Direct knowledge of protein structure must therefore depend upon physical methods of investigation such as X-rays and spectroscopy, etc.

The picture of a globular protein with hydrophilic groups on its outer surface and hydrocarbon groups in contact within the cage is strikingly akin to the picture of the structure of certain micelles to which recent studies have led[15]. Ions, such as cetyl trimethylammonium sulphate, which contain long hydrocarbon chains form micelles in very low concentration. It is found that the size of such particles corresponds to a sphere of radius about equal to the length of the individual molecules and it is shown that the micelles are spherical particles, in which the tails are crowded together in the interior and the hydrophilic heads form the outer surface. The micelles in soap solutions have a similar structure.

Little or nothing is known at present as to the path or the nature of protein synthesis. We see no reason to suppose that a cyclol fabric forms spontaneously from polypeptide chains. If on occasion such cross linking occurs, this is probably a relatively unstable state. The non-formation of cyclol bonds between simple molecules[10,16,17] is thus irrelevant to the cyclol hypothesis and to the problem of the formation of complete globular protein molecules. Using the information obtained in recent studies of protein monolayers formed spontaneously, we deduce that, in the globular state, the CH_2 groups are completely masked from

the aqueous medium. The globular protein in water is thus pictured as having its outer surface predominantly hydrophilic, the hydrophobic groups lying close together in the interior of the cage. A protein molecule of the size of insulin must contain several hundred CH_2 groups to account for the insolubility of the monolayer which it forms. When two CH_2 groups come into contact, energy of the order of 2,000 calories per gram molecule is involved[16], totalling for a protein molecule of the size of insulin, containing at least 300 CH_2 groups, an energy of upwards of 600,000 calories. This suggests one possible factor in the formation of a protein cage molecule.

We would also direct attention to the difference between the stability to be expected when a single cyclol bond forms within or between polypeptide chains and when three cyclol bonds form a triazine ring, and to the still more striking difference to be expected between the stability of a piece of cyclol fabric and of a complete cyclol polyhedron. Undoubtedly there are a number of factors favouring the complete polyhedral structure over and above any uncompleted cyclol structure. These may account for the existence of cyclol cages even if there should be an intrinsic instability in isolated cyclol bonds.

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Remoras or Sucking-Fishes*

By J. R. Norman, British Museum (Natural History)

THE principal characteristic of the Remoras (Echeneididæ), which with the Eocene Opisthomyzonidæ form the order Discocephali, is the oval, laminated, adhesive disk, placed anteriorly on the broad, flat upper surface of the head, and representing the much modified spinous dorsal fin. In the form and position of the remaining fins, as well as in their general osteology, these fishes resemble the Percoids, and especially the families Pomatomidæ, Carangidæ, Rhachicentridæ, etc., and Regan[1] has suggested that they may well have arisen from Percoids of this type. There are about ten existing species, grouped by some into five, by others into only two genera. In any event, they fall into two fairly well-marked groups: the *Echeneis* group, with a long, slender body, usually striped on the sides; and the *Remora* group, with a short, rather robust body, and a uniform brown, grey or black coloration (Fig. 1). Remoras occur in all warm seas, and one species is an occasional visitor to the British coasts. The larger species attain to a length of nearly four feet, but the smaller may not exceed fifteen inches.

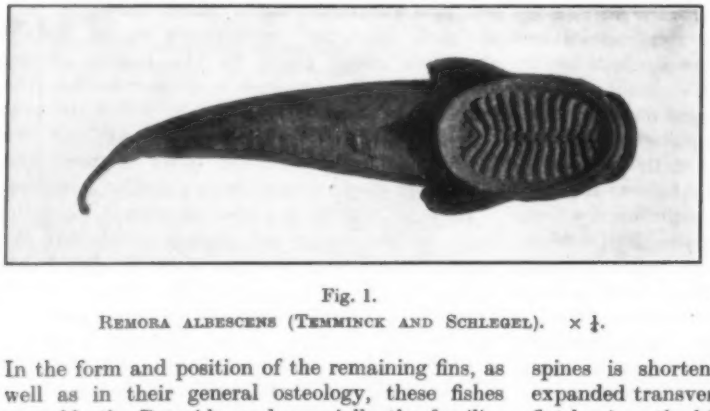

Fig. 1.
REMORA ALBESCENS (TEMMINCK AND SCHLEGEL). × ¼.

In spite of its highly specialized structure, a close study of the cephalic disk reveals all the elements of a spinous dorsal fin[2]. Each of the fin-spines is shortened, depressed posteriorly, and expanded transversely, and forms a pair of broad, flat laminæ, the hinder parts of which are denticulated on their upper surfaces. Posterior projections of each pair of laminæ are connected by ligament medianly, and there is a low fin-membrane joining them to the next pair. Viewed from below, it

* Substance of an address delivered before the Linnean Society of London on November 24.

may be seen that the large overlapping laminæ actually represent the small lateral expansions of the radials generally to be found in the Percoids, and that the basals, although directed very obliquely posteriorly, have an almost normal form. The laminæ composing the disk vary in number in the different species from nine to thirty-six.

It is a little difficult to visualize the manner in which this remarkable modification of the fin has been brought about, but Regan has suggested that the Remoras were probably derived from fishes which had, as the pilot-fish (*Naucrates*) has to-day, the habit of associating with sharks. "The spinous dorsal fin of the pilot-fish, and of other oceanic fishes of the same type, with the spines folded back within a groove, might possibly have some power of adhesion if the edges of the groove were applied to another object and the spines were then slightly raised.'

As to the mechanism of adhesion it seems probable that when the flat surface of the disk is applied to the skin of the host, the marginal membrane creates a partial vacuum and a degree of adhesion is acquired. Then, by a slight raising of the transverse laminæ, a further series of subsidiary vacuum chambers are created and the hold is firmly established. The denticulations on the laminæ are evidently of use in preventing the disk from sliding on the surface of attachment and the fish avoids the danger of being swept away as its host makes its way through the water.

The power of adhesion is remarkable, and when firmly attached a Remora can be dislodged only with difficulty. A backward pull only tends to raise the edges of the laminæ and thus to increase the hold, but by sliding the fish forward, the laminæ are lowered and it can be detached more or less readily. Experiments made with living fishes have shown that a full-grown Remora can withstand a vertical pull of more than 40 lb. without giving way. Sewell[3] has made some interesting observations on living Remoras, and has shown that, while holding on, all movements of the fish, except those associated with respiration (that is, of the mouth and gills) seem to be suspended. "In the case of a fish that had been well hooked, it was found that by allowing the fish to attach itself to a glass plate it would hang motionless, while the hook and a great part of the fish's jaw was cut out!" It appears that the action of the sucker causes inhibition of all movement of the body and tail, and in this connexion a detailed study of the nervous mechanism involved would be of interest.

The Remoras are carnivorous in habit, and, judging from the stomach contents of captured specimens, feed mainly upon other fishes, which they catch freely in the water. They must also obtain a share of the host's meals at times. The advantage of the association to the Remora would seem to be twofold: it obtains transport, without effort on its own part, to fresh feeding-grounds, and it gains a measure of protection from the proximity of its formidable partner. The larger species attach themselves to the surface of the body of the host, generally in the region of the belly or sides, but some of the smaller species are not infrequently found inside the mouths of whales, sharks, giant rays, etc., and others regularly shelter within the branchial cavities of swordfishes, sailfishes, barracoutas and other large teleosts. It has been suggested that the frantic leaps of sail-

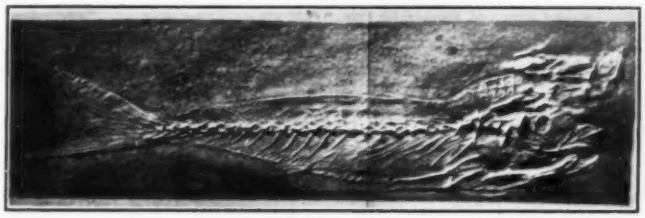

Fig. 2.

OPISTHOMYZON GLARONENSIS (WETTSTEIN). FROM WETTSTEIN. × ABOUT $\frac{1}{2}$.

fishes are made in an endeavour to get rid of the unwelcome guests in the gills. There is some evidence that certain species of Remoras are ordinarily associated with certain definite hosts, but further data are necessary on this head[4].

A fossil Remora—*Opisthomyzon glaronensis* (Wettstein)[5]—from the Upper Eocene of Switzerland, is of considerable interest (Fig. 2). Here the adhesive disk consists of about six segments only, and, in addition to being smaller and narrower than its modern counterpart, is placed farther back and does not reach the interorbital region of the head. Further, the broader opercles and widely forked caudal fin suggest that the Eocene form was a stronger and more active swimmer than its descendants. "Perhaps," as Regan remarks, "it swam more and held on less than they do." The only other fossil Remora so far described is *Echeneis carpathica*, Szajnocha, from the Oligocene of Poland, but this is a comparatively modern form.

As might be expected, the available embryological evidence, although still far from complete, is also of considerable interest. Until recently, nothing at all was known of the early stages in the life-history of these fishes, but in 1926 Täning[6] published preliminary descriptions and figures of

post-larval stages of both *Echeneis lineata* and *Remora remora*, based upon material obtained in the Atlantic by the *Dana* and other Danish vessels under the direction of the late Dr. Johannes Schmidt. His figures show that the disk is developed ontogenetically in the position normally occupied by the spinous dorsal fin, and that it later undergoes a gradual migration anteriorly. Thus, in specimens of *Remora remora* less than 8 mm. in length, no disk is visible. In an example of 9·8 mm. it has the appearance of a narrow oblong structure situated just behind the head: no laminæ are yet visible macroscopically, but can be seen to be developing in prepared sections. In a specimen of 12 mm. the anterior edge of the disk lies just behind the eyes, in one of 18 mm. it is level with their anterior edges, and in one of 25 mm. it is well in front of the eyes. Sanzo[7] has described and figured the pelagic eggs and early larval stages of *Remora remora* from the Mediterranean, but his account adds little to that of Tåning, whose detailed paper will be awaited with interest. Tåning[8] has shown that the pelagic free-swimming post-larval life is of somewhat short duration, since *Remora remora* joins its host at a length of 30–40 mm., while at a length of 50 mm. the adhesive disk of *Echeneis lineata* has attained its full efficiency.

In the later stages of development, it may be noted that in the species of the *Echeneis* group the young have a peculiar type of caudal fin, the middle rays being prolonged to form a narrow pointed process. This gets progressively shorter with age, the hinder margin of the fin becoming plumose and finally more or less concave[4].

There is a notable and persistent myth or legend associated with the Remoras, concerning the alleged powers of these fishes to retard the progress or even to stay the course of a ship[9]. This idea is inherent in the names given to the fish by the Greeks and Romans—*Echeneis* (one that holds back a ship) and *Remora* (a holding back). The earliest reference to the fish itself is that of Aristotle, but there seems to be reason for supposing that he never saw the fish in the flesh. The fact that he refers to it as a fish "which some call the *Echeneis* or 'ship-holder' " suggests that the belief was already current in the fourth century B.C. The credit for the first definite reference to the ship-retarding powers of the Remora belongs to Ovid, but the most detailed account is that of Pliny. The latter asserts that the naval battle of Actium was lost by Mark Antony because at the critical moment the prætorian ship was delayed by a fish of this kind. He also tells us that the death of the Emperor Caligula was presaged by a Remora arresting the progress of his galley on the voyage to Antium. In addition to stopping a ship, states Pliny, a Remora could stay or hasten an *accouchement* or a law-suit! Later writers repeated this legend, with or without embroideries, and it remained popular throughout classical, medieval and renaissance times. It is of some interest to note that the term Remora has attained a definite place in literature, especially in English literature of the sixteenth and seventeenth centuries. Rabelais, in order to illustrate the law's delays, refers to "your beneficial remoras, that is the eternity of law-suits: the needless let that keeps them undecided". Spenser, in his "Visions of the World's Vanitie", has the following:

"All suddenly there clave unto her keel
A little fish that men call Remora,
Which stopt her course, and held her by the heel,
That wind nor tide could move her thence away."

Also Ben Jonson applies the term to describe a tedious bore (Poetaster), thus:

"Death, I am seized on here
By a land remora."

Various attempts have been made to illustrate the legend, and one of the more curious is shown in Fig. 3. This is to be found in the "Ortus Sanitatis" of Johann von Cube, first published at the end of the fifteenth century, and shows some six or seven Remoras adherent to a ship.

Fig. 3.
ONE OF THE EARLIEST KNOWN FIGURES OF *Remora* OR 'SHIP-HOLDER'. FROM JOHANN VON CUBE'S "ORTUS SANITATIS" (2ND ED., LEIPZIG, 1490).

Although it is possible that a number of attached Remoras might retard somewhat the progress of a small boat, it is inconceivable that one (or even a dozen) fish could exert sufficient power to affect the course of a vessel of any size. As Gudger[9] has pointed out, the more probable explanation of a ship being suddenly held up or losing way is a physical one—the phenomenon known to seamen as 'dead-water'.

In various parts of the world the natives make use of leashed Remoras to capture large fishes, dugongs, turtles, etc., and many accounts have been given by travellers and others of the methods employed[10]. Often a ring is fastened round the

Remora's tail, and to this is attached a long cord. The fish is kept in a bucket of water until, say, a turtle is sighted near the surface, and it is then released so that it may attach itself to the quarry :

Fig. 4.

FISHING WITH THE REMORA. FROM CONRAD GESNER'S "HISTORIÆ ANIMALIUM", LIB. 4, 1558.

Remora and turtle are then pulled in together. Some skill is required in playing the 'catch', for any undue strain on the line may detach the Remora or, what is more probable, pull the ring from its tail. In the Torres Straits, according to Dr. A. C. Haddon, a hole is bored through the tail, and through this a line is passed and made fast. A second line is passed through the jaws and out through the gill-openings. When the canoe sets out the fish is towed through the water by the head-line, and if it should attach itself to the boat it can be released by a forward pull when required.

What appears to be the earliest account of the employment of the Remora in this way occurs in Peter Martyr's account of the second voyage of Christopher Columbus to the New World, published in the early part of the seventeenth century. The story has been repeated by many writers of this and later times, and appears in the early works on natural history of Gesner (Fig. 4), Aldrovandi and others.

[1] Regan, *Ann. Mag. Nat. Hist.*, (8), **10**, 634 (1912).
[2] Beck, "Ueber die Haftschiebe der *Echeneis remora*", Inaug. Diss. Schaffhausen (1879); Storms, *Ann. Mag. Nat. Hist.*, (6), **2**, 67 (1881); Houy, *Zool. Jahrb. Abt. Anat.*, **29**, 101 (1909).
[3] Hora and Sewell, NATURE, **115**, 48 (1925).
[4] Gudger, *Amer. Mus. Novit.*, No. 234 (1926).
[5] Wettstein, *Mem. Schweiz. Palaeont. Ges.*, **13**, 82, pl. VII, Fig. 10 (1886).
[6] Tâning, *C.R.*, **182**, 1293 (1926).
[7] Sanzo, *Mem. Com. Talass. Ital.*, **138**, 1 (1928).
[8] Tâning, NATURE, **120**, 224 (1927).
[9] Gudger, *Ann. Mag. Nat. Hist.*, (9), **11**, 271 (1918).
[10] Gudger, *Amer. Nat.*, **53**, 289, 446, 515 (1919).

Obituary Notice

Mr. Emile Mond

MR. EMILE MOND died at the age of seventy-three years on December 30, 1938. He was a nephew of the late Dr. Ludwig Mond.

Emile Mond received his early education in Paris at the Collège de Sainte Barbe and at the Lycée Condorcet and specialized in chemistry at the Polytechnicum, Zurich, where he took his diploma. He began his technical career in England with Brunner, Mond and Co. with whom, at first, he did not stay very long, leaving them to found the West Indies Chemical Works in Jamaica with his friend and former fellow-student, Dr. Emile Bucher of Geneva. Afterwards, he returned to Great Britain and became technical assistant to his uncle, specializing in patent work. Later, he joined the board of Brunner, Mond and Co., Ltd., and the Mond Nickel Co., Ltd., becoming vice-chairman of the latter. In addition, he held the chairmanships of the South Staffordshire Mond Gas Co., the Power-Gas Corporation, Ltd. and Ashmore, Benson, Pease and Co., Ltd.

Emile Mond married Angela, youngest child of the late James Henry Goetze, who has been so closely identified with his many benefactions and scientific and social activities. From its beginning, he was intensely interested in the Institut Français du Royaume Uni which was founded by Madame Marie Bohn and, being greatly concerned at the lack of educational facilities in Great Britain for French and Belgian refugee children, he provided for the establishment of the Lycées de Londres in May, 1915. These institutions became so important that the British Government provided a house for them and the Lycées became part of the Institut Français. Later, in 1921, they were formally recognized by the French Government and affiliated to the Université de Lille. In recognition of this important work, Emile Mond was made Officier de la Légion d'Honneur by the French Government and Officier de l'Ordre de Léopold by the King of the Belgians. In 1919, Emile Mond established the 'Francis Mond' professorship of aeronautical engineering—the first chair in that subject in a British university—at Cambridge in memory of his son, who was killed while flying in France in May 1918.

Although he always under-estimated his own ability and attainments in the science, Emile Mond was keenly interested in the advancement of chemical knowledge and, when he could spare the time, delighted to visit laboratories where original investigations were proceeding and invariably was able to contribute usefully to the discussion of the results. It was this interest in the subject and his desire to help in the attainment of new knowledge which led

him to accept the honorary treasureship of the Faraday Society in 1930, succeeding his cousin, the late Sir Robert Mond, and in 1931 he also became honorary treasurer of the Chemical Society. The work of this latter office is particularly onerous, and Emile Mond never spared his efforts on behalf of the Chemical Society and of the Faraday Society. His work was carried out with meticulous care and foresight, and during the time he has looked after their affairs—he held both offices at the time of his death —the two Societies have made outstanding progress, and the publication and discussion of new knowledge in chemistry have been greatly extended.

Emile Mond was a man of rare discernment, great modesty and charm. Severely critical of his own efforts, he was always appreciative of those made by others. Only a few have any idea of his great generosity during many years, and this generosity was guided by his intense desire to help the younger generation, to advance science and other branches of knowledge and to extend international good will. For many years, Mr. and Mrs. Emile Mond have made their houses delightful centres of refinement and culture for their numerous friends in this and many other countries.

Emile Mond was a type of man unfortunately too rare in these days. His greatest happiness was in helping others towards a fuller appreciation of things that are worth while. He will be greatly missed, and to Mrs. Mond and the family very many who were privileged to know this truly great man will wish to tender their deepest sympathy.

CHARLES S. GIBSON.

WE regret to announce the following deaths:

Prof. G. Barger, F.R.S., regius professor of chemistry in the University of Glasgow, on January 5, aged sixty years.

Mr. J. O. Borley, O.B.E., formerly fisheries adviser to the Colonial Office, known for his work with the "Discovery" Committee in connexion with the international control of whaling, on December 30, aged sixty-six years.

Mr. Reynold Bray, ornithologist of the British Canadian Arctic Expedition, aged twenty-seven years.

Prof. H. A. Cummins, C.M.G., emeritus professor of botany in University College, Cork, on December 31, aged seventy-four years.

Sir Robert McDougall, known for his services to the National Trust and his interest in agricultural research at Rothamsted, on December 15, aged sixty-seven years.

Prof. M. Pavlova, professor of palæontology in the University of Moscow, aged eighty-four years.

Prof. L. G. Schnirelman, professor of mathematics in the University of Moscow, aged thirty-one years.

News and Views

Sir Frank Smith, G.B.E., K.C.B., F.R.S.

SIR FRANK EDWARD SMITH will relinquish on January 31 his appointment as secretary to the Committee of the Privy Council for Scientific and Industrial Research, a post which he has held with distinction for the last ten years. Born in Birmingham in 1876, he gained a national scholarship in physics at the Royal College of Science in London. He was one of the first assistants appointed by the late Sir Richard Glazebrook when the National Physical Laboratory began in 1899, and he was superintendent of the Physical Department of the Laboratory from 1901 until 1920. During this time he did a great deal of advanced original research work, introducing many novel methods, but he was never satisfied with the results obtained until he had checked them by other methods. He designed and helped to construct many new instruments and devices, and his results on the measurement of absolute units showed an accuracy unrivalled at the time. Accounts of many of these researches, some of them written by himself, will be found in Glazebrook's "Dictionary of Applied Physics", vol. 2. The gradual evolution of the current balance, in which the electric attractions between currents in coils were balanced by weights, so that it became possible to measure a current in absolute measure and thus determine the ampere, was a triumph of research. The agreement now arrived at by international physicists as to the absolute value of the units justifies the great skill and time expended in measuring them, in which Smith took a leading part. In addition to all the routine and research work he did, he was always pleased to discuss with his colleagues the problems in which they were mutually concerned. Among other important work he did at the Laboratory was his work on the 'current weigher' in collaboration with Ayrton and Mather. He co-operated with Duddell and Glazebrook in perfecting radio telegraphic apparatus for direction finding, and he also co-operated with some of the physicists at the Bureau of Standards, Washington, D.C., in perfecting standards of electromotive force. His work with Rosa of this laboratory on standards of inductance was also of great value.

FROM 1920 until 1929, Sir Frank was director of scientific research, Admiralty; from 1929 until the present time he has been secretary to the Department of Scientific and Industrial Research. He has been one of the secretaries to the British Association for Advancement of Science (1922–29) and a secretary of the Royal Society from 1929 until 1938. As an administrator he has been most successful, partly due to his tact and the many friendships he formed with leading men in the industrial and engineering

world. He forms an admirable link whereby the industrialist can get into touch with Government departments—and vice versa. During recent years, in furtherance of his duties, he has made voyages to South Africa, the Argentine, the United States, etc. He has been of great service to the Royal Society and has given lectures, generally in connexion with electrical subjects, to many scientific and industrial societies in towns in all parts of the kingdom. He has been president of the Physical Society and of the Junior Institution of Engineers, and has been given various degrees by universities in Great Britain and abroad. He has been awarded the Hughes Medal of the Royal Society, the Duddell Medal of the Physical Society and the Faraday Medal of the Institution of Electrical Engineers. All men of science will hope that his advice will be available to us for many years to come.

Prof. E. V. Appleton, F.R.S.

H.M. THE KING has approved the appointment of Prof. E. V. Appleton to succeed Sir Frank Smith as secretary to the Committee of the Privy Council for Scientific and Industrial Research. Prof. Appleton, who will take up his new appointment on February 1, has been Jacksonian professor of natural philosophy in the University of Cambridge since October 1936. He is a fellow of St. John's College, Cambridge; and, after a period of service on the staff of the Cavendish Laboratory, he held the post of Wheatstone professor of physics in the University of London during 1924–36. Prof. Appleton's research work has included a study of the operation of thermionic valves and their associated circuits, the nature and origin of atmospherics and the phenomena associated with thunderstorms; but he is perhaps best known for his investigations on the ionized regions of the upper atmosphere, and their influence on the propagation of radio waves. In this field the results of his work have been of far-reaching importance both in connexion with our knowledge of the physics of the atmosphere and also in assisting the general development of long-distance radio communication. It is well known that by using waves sufficiently short to penetrate the Heaviside layer, Prof. Appleton was able to demonstrate the existence of a second, similar but denser, ionized region at a greater altitude. Most of this research has been conducted on behalf of the Radio Research Board, of which Prof. Appleton has been a member for many years. The work itself has brought him international recognition: he was awarded the Morris-Liebmann prize of the American Institute of Radio Engineers, in 1929 and was elected a vice-president of the Institute in 1932. He has been president of the Union Radio Scientifique Internationale since 1934, and in this capacity he conducted the general assembly of the Union which took place in Italy last September.

Prof. P. G. H. Boswell, O.B.E., F.R.S.

PROF. P. G. H. BOSWELL, who has resigned from the professorship of geology at the Imperial College, is followed by Prof. H. H. Read, who succeeded him as George Herdman professor at the University of Liverpool. After some early work on the glacial deposits of eastern England, Prof. Boswell's researches on the Tertiary rocks of the London Basin extended the study of detrital minerals originated by H. H. Thomas to the elucidation of problems of genesis, provenance and age. He thus gave a new life and meaning to the old "test by included fragments", inaugurated a method of research which has been widely followed, threw new light upon processes of sedimentation, and laid the foundation for his work on sands and other mineral substances of vital importance to the metallurgical, glass and brick-making industries during the War. He also devoted much attention to the Chalk, its movements and its sub-Tertiary surface, to the history of the Suffolk rivers, to the Pliocene 'Crags', and to the classification of the Glacial Drifts especially in their relation to early man, on which he gave his presidential address to Section C of the British Association at York. As an authority on East Anglia, his services were called upon by the Geological Survey for three of its memoirs, while he contributed a series of articles to the "Encyclopædia Britannica" and to "Regionale Geologie" and its successor the "Handbook of the Geology of Great Britain"

WHEN Prof. Boswell moved to Liverpool to take the chair of geology there, he tackled the difficult area of the Denbighshire Moors, which had been long neglected by geologists, and started a series of papers on their geology which he has since continued. He was able to give advice on the geological conditions of the Mersey valley which contributed no little to the success of the new tunnel; and, later, he was sent out to adjudicate on disputed evidences on the age of human skeletons obtained from Kanam and Kanjera in Kenya. In spite of all this research and the stringent duties of his chair, he found time to make a translation of Heritsch's "Nappe Theory on the Alps", which an eminent German professor was heard to say he preferred reading to the original. He has acted as president of the Prehistoric Society, as secretary of the Geological Society, and as a general secretary and treasurer of the British Association. In his latter positions he has taken an active part in the recent increased activities of that body. We may look forward with confidence to a rich harvest of further research from him now that he is free from the heavy strain of professional duties.

Technical Non-Teaching Staff in Laboratories

AN important unit on the science side of educational establishments is that which includes the minor technical staff, namely, laboratory and technical assistants, workshop assistants, store keepers, etc., and science teachers know from experience the help which a really good laboratory assistant renders to a department. This is particularly the case in those departments which employ only one assistant. His experience, probably gained from the problems encountered while performing the tasks associated with his post, covers a wide range, depending upon the particular type of science department in which

he is engaged. One agrees that the services rendered by these assistants should be adequately recognized from a financial point of view. In addition, their conditions of service should be such that they are encouraged to take a real interest in their work, and are given facilities for proper training. There is no need to stress examples of such assistants attaining the highest academic distinctions; but it is a fact that many of them, given help and encouragement, display marked resources, particularly in experimental technique. The conditions of employment are not too good in some institutions, and so within the past three or four years a Technical Non-Teaching Staff Branch of the National Union of Public Employees has been formed to safeguard the interests of such technical assistants.

THE objects of this branch, which is of national character, although its activities have been confined mainly to London, include the following: to improve the status of all stewards and assistants employed in the laboratories, or workshops, of any educational establishment, and to secure a fair wage, reasonable hours of work, suitable working conditions, together with a reasonable expectation of permanent employment. One obvious difficulty is the grading of assistants in university laboratories with those employed in secondary schools. There is no comparison between the ability, responsibilities and skill of the members in the two classes. It must also be remembered that salaries and conditions of employment in educational institutions are bound to vary with the locality. The Branch of the Union is also endeavouring to organize suitable training courses for juniors, and specialized practical classes for others. It is proposed that these classes shall extend over a minimum period of five years, the final specialization being in biology, chemistry or physics—for some reason no mention is made of engineering. After successfully passing through the courses, the candidate would be entitled to receive a nationally recognized certificate, or diploma, which would be a guarantee of competence in laboratory management. It must be remembered, however, that the Institute of Physics has a scheme in operation, whereby certificates are awarded to technical assistants in physics who attend approved courses of instruction, and pass examinations in accordance with certain regulations. Other activities of the Branch of the Union include educational visits to laboratories, factories, etc., and it is hoped to arrange for demonstrations of new apparatus, experiments, etc., similar to those held in connexion with other associations. The secretary of the Branch is Mr. E. J. Chilton, 361 Kingston Road, Ewell, Surrey.

Data on the Ionosphere (F_2 Region)

IT is important to the radio engineer to know the highest frequency radio waves returned from the ionosphere at any time or season, since this critical frequency represents the division between those frequencies which can be used for long-distance radio communication and those which are suitable for transmission only over quasi-optical ranges. The same knowledge is of importance also to the geophysicist, since it provides him with a reasonably accurate statement of the most intense ionization existing at any level in the ionosphere. For some years past, the Radio Department of the National Physical Laboratory has conducted a comprehensive investigation into the propagation of waves as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research. Included in this work are daily measurements of the height and critical frequencies of the various regions of the ionosphere made at the field station of the Radio Department at Slough (lat. 51° 29′ 30″ N., long. 0° 33′ 30″ W.). When electric waves from a radio transmitter pass through the ionosphere, they are split into two components with different velocities and opposite senses of circular polarization, under the influence of the earth's magnetic field. The region capable of returning the higher radio frequencies to earth is known as the F_2 region and the highest frequency which can just be returned by that region is known as the critical frequency and refers to the extraordinary component of the wave. It is, however, more convenient to measure the ordinary component, and in the northern hemisphere the plane of polarization of this component has a left-handed direction of rotation when looking along the direction of propagation. The critical frequency for this component is generally about 0·7 Mc./s. lower than that of the extraordinary component in the case of the results quoted. The daily measurements are carried out with waves returned from the ionosphere at vertical incidence, and the values of height and critical frequency of the regions studied refer to this condition. The corresponding values for oblique incidence can be derived from these results, and from these, the conditions for long-distance communication can be deduced.

IN view of the widespread use of long distance radio communication and broadcasting on the short wave band between 10 and 100 metres (3 and 30 Mc./s.), it is proposed that the ionospheric data relevant to this band should be made available as a special service to those interested in the subject. Typescript copies of monthly tables, including sufficient data for any day to enable a simple curve to be plotted showing the relation between height and critical frequency of the region under consideration, and beginning with January 1939, is now available at 2*s*. 6*d*. per annum for subscribers in Great Britain or in the Empire overseas, and 5*s*. per annum for foreign subscribers. Applications, with the appropriate remittance, should be addressed to the Director, National Physical Laboratory, Teddington, Middlesex. Arrangements have also been made by which those desiring to obtain early information on the state of the ionosphere as soon as the data are available may obtain them by telephoning the Radio Research Station (Slough 1560) between the hours of 10 a.m. and 4.30 p.m. Those wishing to avail themselves of this service should write to the Director of the National Physical Laboratory asking

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NATURE

SUPPLEMENT

Vol. 143 SATURDAY, JANUARY 14, 1939 No. 3611

Science and Faith

THE meeting of the American Association for the Advancement of Science, which took place at Richmond, Va. during December 27–31 will be memorable in the annals of science as being the first to mark that closer co-operation between this body and the parent British Association, to which Lord Rayleigh, in his presidential address to the latter body at Cambridge in August last, looked for aid in promoting international amity. No less will it be remembered as the occasion of the delivery of the two addresses of which the main parts are given in the following pages.

In these pronouncements, two of the leaders of scientific thought in the United States and Great Britain at the present day, Prof. G. D. Birkhoff, the president of the American Association, and Sir Richard Gregory, chairman of the newly formed Division for the Social and International Relations of Science of the British Association, declared their faith in the mission of science in the resolution of the maladjustments which lie deep-seated at the root of the difficulties and the dangers with which the world of to-day is faced. In the words of Prof. Birkhoff, "The increasing number of un-co-ordinated theories and mechanical inventions confuse and chill many of us. Man is felt to be a tragic detail in a vast incomprehensible whole, and the old sense of values seems to become less and less real". But he went on to show in his lucid analysis of the function of intuition, reason and faith in the approach to his hierarchy of five ascending levels in the nature-mind spectrum, that while reality is to be attributed to each and all, at each level there is an ever-widening succession of abstract ideas, each explaining imperfectly some aspect of the stupendous whole; but that at the social level a fundamental truth of transcendent importance is truth and good will in all social relationships. In concluding that a new injunction has been laid upon the spirit of man to know and to understand ever more broadly and deeply, he added that in the daring effort of the man of science to extend knowledge there arises a spontaneous faith which is the most powerful incentive and the best guide to further progress.

In essence, Sir Richard Gregory's address is complementary to that of Prof. Birkhoff. Just as Prof. Birkhoff holds that faith in the ultimate truth of certain fundamental principles is the guiding star of the man of science, so Sir Richard shows that in the study of man and society from the earliest ages it is seen that faith in an unseen power which lies behind the appearance of things is a fundamental component of man's nature. He goes on to demonstrate that, in the course of the development of mankind, faith also has developed, not only in the conception of the object of devotion and the relation of that object to the universe, but also in the extension of the circle of those to whom the ethical system which is its accompaniment is made to apply. Although it has to be admitted that the development of spiritual and ethical concepts has been retarded in comparison with material development, nevertheless it is in the recognition of this conception of a process of continuous development in theological and ethical ideas that Sir Richard sees hope for the ultimate approach one to the other of religion and science, while in the fundamental urge of faith he sees a guide pointing the way to an enlargement of the ethical ideal, in which present differences and antagonisms may be resolved.

Intuition, Reason and Faith in Science*

By Prof. George D. Birkhoff, Harvard University

FROM the earliest times scientific ideas, even when crudely conceived, have been of immeasurable importance, not only for man's material advancement and control over Nature, but also in modifying and expanding his philosophic and religious outlook. In the effort to obtain a better understanding of his place in the cosmos, he is compelled to proceed largely by considerations of analogy based upon supposed or actual fact. So he turns more and more toward the ever-widening vistas suggested by science in its continual discoveries of new truth.

To-day, the significance of science as a principal source of revelation is almost universally recognized. Thus recently, on behalf of Pope Pius XI, Cardinal Pacelli spoke before the Pontifical Academy of Sciences concerning the enlightenment that comes from "the potent streams of the natural and rational sciences and the great river of revealed wisdom". He said that the former are found "wherever man looks for and finds truth". As for "the great river of revealed wisdom", is it not to be found in all the absolutely sincere utterances of poets, philosophers and prophets, based on the relevant knowledge of their day and made after deepest meditation? It would seem that such utterances are in essence similar to the pronouncements of the scientist. Is not the vague, prophetic conjecture of Pythagoras that Nature is mathematical as true as Newton's more precise law of gravitation? From this point of view, the great streams of revelation seem to merge insensibly into one.

Nevertheless, the immediate effect of scientific advances is often very disquieting. The strong opposition long shown to the Darwinian theory of evolution bears witness to this fact. Similarly at the present day, the ever-increasing number of unco-ordinated theories and mechanical inventions confuses and chills many of us. Man is felt to be a mere tragic detail in a vast incomprehensible whole, and our old sense of values seems to become less and less real.

To persist in such an attitude of discouragement is unjustified. Every individual has implanted within him the desire to understand his role in the existing order. He feels an inalienable right to find out his duties and privileges as a citizen of the universe. By the light of any new knowledge he is always certain to gain deeper insight into his position. The wise advice of our own great Emerson comes to mind: "Fear not the new generalization. Does the fact look crass and material, threatening to degrade thy theory of spirit? Resist it not: it goes to refine and raise thy theory of matter just as much."

What, then, are some of the larger points of view which are suggested by science to-day? In attempting a reply, I can of course only offer a personal interpretation, inevitably reflecting the fact that I speak as a mathematician having some acquaintance with physics.

Let us observe in the first place that our universe presents antipodal aspects—the objective and the subjective, the impersonal and the personal. If we take the objective aspect as more fundamental, we put our emphasis on the notion of reality; and if we start from the subjective, we prefer to speak of knowledge. In either case we are able to discern a kind of nature-mind spectrum; for there appears a roughly given hierarchy of five ascending levels—mathematical, physical, biological, psychological and social. Each level has its appropriate special language. The basic corresponding concepts are respectively: *number* at the mathematical level; *matter* at the physical level; *organism* at the biological level; *mind* at the psychological level; and *society* at the social level. If we choose to select one of these as somehow more real than the others, a great distortion arises in our point of view. For example, if we regard the physical level as the most fundamental, we become materialists. But why make such an unnecessary choice? The languages of the various levels are essentially independent of one another, and the observed laws are best expressed in their own natural terms. Why mix up the levels of knowledge unnaturally? Does it clarify our idea of social justice to try to explain it in terms of the reactions between protons and electrons in the brain?

* From the address of the president of the American Association for the Advancement of Science delivered at Richmond, Va., on December 27, 1938.

These considerations bring us to a first general point of view towards the levels of knowledge: it is desirable to accord reality in equal measure to all kinds of knowledge everywhere, and so to view the universe as broadly and impartially as possible.

Another very important observation is that in order to understand the various facts and their interrelations we must always use abstractions, that is, conceptual tools of a logical or mathematical nature. Contrary to opinions which prevailed until recently, any abstraction serves only limited specific ends. At best it will enable us to grasp more clearly some small fragment of reality. For example, by use of the abstraction of Euclidean geometry, and in that way alone, we understand the nature of space with a considerable degree of exactitude; and yet to-day scarcely any physicist would ascribe objective reality to space in itself. It has been Einstein more than anyone else who has taught the scientific world the true role of Euclidean geometry by means of his theories of space-time and relativity. More generally, we have come to realize that our only approach to a better understanding of the world is by means of a widening succession of abstract ideas, each explaining imperfectly some aspect of the stupendous whole. This is a second synthesis deserving of especial emphasis.

Thirdly, I would state a fundamental truth about the social level, which in some sense is the highest level of all: the transcendent importance of love and good will in all human relationships is shown by their mighty beneficent effect upon the individual and upon society.

Thus I have begun by presenting very briefly three important articles of my personal faith. It is my especial purpose to show how this phenomenon of faith arises inevitably in the mind of the scientist whenever he tries to evaluate technical conclusions in his special field. In doing so I shall discuss the role of intuition, reason and faith in science, first at the mathematical and physical levels, and then more briefly at the biological, psychological and social levels. This will lead me in conclusion to formulate two other items of my personal *credo* in the hope that they may be worthy of attention.

By way of definition it must be indicated first what is meant by intuition. There are certain elementary notions and concepts which come spontaneously to the minds of all who observe, experiment with and reflect on a specified range of phenomena. Such generally accepted ideas or intuitions constitute the consensus of reaction of intelligent men to a certain part of the world of fact. John Stuart Mill has said, "The truths known by intuition are the original premises from which all others are inferred." It is in this sense that I shall refer to intuition. By reason I shall mean the rational superstructures which may be erected upon the basic intuitive ideas by means of deductive or inductive reasoning. These superstructures will also be accepted by all who are able to follow the sequence of logical steps involved. By faith I shall mean those heuristically valuable, more general points of view, which are beyond reason, and sometimes in apparent contradiction with one another, but which to the individual concerned seem of supreme importance as he endeavours to give his conclusions the widest possible scope.

It is clear that in this way we obtain a basic classification of knowledge into three easily distinguishable types. Let us consider the occurrence of these types at the various levels of knowledge.

Intuition in Mathematics

By continual crude experimentation with classes of concrete objects, man has come gradually and inevitably into the possession of certain numerical ideas. In particular he has been led to think of the positive integral numbers 1, 2, 3 . . . as entities which exist in almost the same sense as the objects themselves. This concept finds its realization in the designation of the integers by corresponding marks 1, 2, 3 . . . Such integers are found to be subject to certain simple arithmetic laws, and these laws are regarded as intuitively true.

The integers form the basis of a great part of mathematics. For it is found that with their aid one may construct fractions and, more generally, real and imaginary numbers. In the course of the centuries, mathematicians have thus built by processes of pure reason the elaborate structures of algebra, the theory of numbers and analysis. An extensive array of beautiful and useful theorems has been deduced.

Similarly in geometry—which in its origin may be regarded as the most elementary branch of physics—we experiment with rigid material objects and arrive readily at the notions of idealized small rigid bodies or 'points' and of idealized 'lines' and

'planes'. Then we observe that certain postulates hold, such as the familiar ones of Euclid. By means of these postulates which embody our intuitions, we are able by deductive reasoning to arrive at other geometrical theorems, including such results as the celebrated Pythagorean theorem which shows us in particular that a right triangle with legs of 3 units and 4 units in length has a hypotenuse of exactly 5 units in length. The vast mathematical domain called 'geometry' has arisen from these elementary geometrical facts as a primary source.

There are many other abstract mathematical structures besides those just alluded to. In all cases it is found that they are made up of certain accepted intuitions (or postulates) and their logical consequences.

Now what I desire particularly to point out is that the mathematician goes far beyond such generally accepted clean-cut assumption and conclusions, in that he holds certain tacit beliefs and attitudes which scarcely ever find their way into the printed page. Yet these form none the less part of a considerable oral tradition. For example, he believes in the existence of various infinite classes, such as that made up of all the integers. He believes also that the whole body of strict logical thought called mathematics is self-consistent: in particular, when he finds that the number π admits of diverse forms of expression, as, for example,

$$\pi = 4\left[\tfrac{1}{1} - \tfrac{1}{3} + \tfrac{1}{5} - \tfrac{1}{7} + \ldots\right]$$

and

$$\pi = 2\sqrt{3}\left(\tfrac{1}{1}\,\tfrac{1}{1} - \tfrac{1}{3}\,\tfrac{1}{3} + \tfrac{1}{5}\,\tfrac{1}{9} - \ldots\right),$$

he feels absolutely certain that if the unending calculations could be fully carried out, the results would be exactly the same in all cases. Furthermore, when he recalls that in the past the most difficult mathematical questions have been ultimately answered, he is inclined to believe with the great German mathematician, Hilbert, that every mathematical fact is provable. Besides all this, he attributes certain values to his results and their mathematical demonstrations: some theories seem important; some proofs are regarded as elegant, others as profound or original, etc.

Such somewhat vague ideas illustrate what I would call mathematical faith. Nearly all the greatest mathematicians have been led to take points of view falling in this broad category, and have attached the deepest significance to them.

What I wish to emphasize concerning this generally overlooked aspect of mathematical thought is that on one hand, the beliefs involved have been of the utmost heuristic importance as instruments of discovery, and, on the other hand, when examined in detail they generally turn out to involve ideas which are held true or false, according to the specific definitions which may be afterwards adopted.

Suppose, for example, that we turn to the first question of the existence of infinite classes. There was no question about the unconditional acceptance of such classes until within a few decades, although a few, like the ancient Greek philosopher Zeno and the German algebraist Kronecker, profoundly distrusted the use of the infinite in mathematical reasoning. To-day, however, due primarily to the theory of transfinite aggregates created by Georg Cantor about fifty years ago, mathematicians have come to realize that such an infinite class may exist in the so-called 'idealistic' sense but not in the sense of explicit constructibility. Thus the class of all collections of positive numbers less than 1 exists in the idealistic sense, but not in the alternative, more concrete sense.

A similar situation has arisen in the detailed study of the self-consistency of mathematics. It has appeared that very limited parts of mathematics can be proved self-consistent. But such a general assertion as that "the whole of mathematics is self-consistent" would be considered to-day not to be sufficiently precise; and each time that the proof of self-consistency is extended further, a definite logical price has to be paid in that certain so-called metamathematical ideas are tacitly employed, which need themselves to be investigated in the same respect. For example, the work on the foundations of logic by Whitehead and Russell (1910) showed that if the notion of class was not restricted, certain logical paradoxes would inevitably result. For this reason a theory of the 'hierarchy of types' was devised by them, which limited the notion of class and so avoided the apparent inconsistencies. We are thus entitled either to say that mathematics as of the year 1900 was self-consistent or was not, according to the point of view which is adopted. In any event the belief in question has led us to a much deeper insight into the nature of logic.

With regard to the unlimited power of mathematical demonstration, it has been recently proved by the Austrian mathematician Gödel that, if we restrict ourselves to reasoning of an ordinary

type, there exist explicit 'undecidable' theorems, while from a higher metamathematical point of view such a theorem might be demonstrable. Hence Hilbert's affirmation is in one sense false. But despite this fact, the open question on which he focused attention is much better understood than ever before.

Likewise in the question of value in mathematics, such as the importance of theories, or the elegance, profundity and originality of proofs, it is clear that these obscure ideas depend in large measure upon the momentary state of the science. Thus the theory of functions of an imaginary variable and classical geometry were regarded as extremely important a quarter of a century ago; while to-day the theory of functions of real variables and the basic kind of geometry called analysis situs have respectively displaced these subjects in general mathematical esteem. It would be hard to explain adequately the reasons for this change, but the increasing role of discontinuous quantity in physical theory and the relativistic point of view towards space and time have certainly been contributing factors.

An excellent instance of the power of individual mathematical faith in bringing about creative advance has been afforded by an American mathematician, the late Eliakim Hastings Moore. Moore was a thorough-going abstractionist who believed that mathematics itself should be reorganized from a still higher point of view by the dissection of essential common parts out of apparently different abstract fields. His point of view was strongly confirmed by the analytic work of Hilbert and Erhardt Schmidt near the beginning of this century. So Moore was led to create his 'general analysis' in 1906. This aimed at embodying his conviction that "The existence of analogies between the central features of various theories implies the existence of a general theory which underlies the particular theories, and unifies them with respect to these central features."

As time has elapsed, the deep truth of Moore's contention has been amply sustained. Indeed one of the most active schools of contemporaneous mathematical thought follows the higher abstract point of view adopted by Moore. But it has been found necessary to modify Moore's programme in that instead of a single 'general analysis' serving as an *omnium gatherum*, it has been desirable to employ a few typical forms. In this way his faith in the power of higher abstraction has been largely and yet not fully justified.

A good many mathematicians are seriously hampered by lack of the ardent positive faith which Moore showed. This type of deficiency is generally due to a strong development of purely critical powers and to over-specialization. Several times I have observed this lack in myself only to be counteracted by definite effort. For example, I did not make active use of the fundamental integral of Lebesgue for a long time, and so was prevented from pursuing to their natural conclusion certain ideas which finally led me to establish the basic 'ergodic theorem' in 1931. Here I was finally converted, as it were, to the use of this tool by the important advances of Koopman and von Neumann, and in particular by the latter's proof of the 'quasi-ergodic theorem'. It is worthy of note that the related ergodic hypothesis goes back in its origins to the physicists Boltzmann and Maxwell.

Space, Time and Force

Let us turn next to the physical level, where the corresponding situation is at least equally interesting.

If we accept the ordinary conceptions of space and time, which seem destined always to play a basic role in workaday physics, we find that the simplest physical ideas are those which arise through the manipulation of massive bodies. As these ideas have become clarified, they have been given abstract formulation in terms of such concepts as those of mass, force, etc. Newton's celebrated three fundamental laws of motion embody the final form of the refined intuitions thus arrived at. With these as a basis and the acceptance of certain further special observed laws, one may deduce by mathematical reasoning the theory of mechanics as applied, for example, in the solar system.

Similarly, through experimentation with electrified bodies, electric currents, magnets, etc., there was developed by Faraday the intuitive ideas of electric and magnetic lines of force which are now generally accepted. Later, Maxwell incorporated these ideas in the appropriate electromagnetic equations. Upon this basis all classical electromagnetic theory has been logically constructed. Furthermore, by means of the identification of the light wave and the electromagnetic wave, due to Maxwell, an adequate theory of light has been obtained.

Thus we see the important part which intuition and reason have played in two fundamental

branches of physics—mechanics and electromagnetism. A cursory survey of the various other branches of the subject would show that a similar situation holds throughout, except in the rapid developments of quantum mechanics during the last decade or so. In this strange theory the physicist begins indeed with a planetary model of the atom, reminiscent of Niels Bohr's earlier theory. But a flying leap is made from this temporary scaffolding to what is thenceforth regarded as the only basic reality—the wave equations of Schrödinger and, better still, of Dirac. Once having arrived at these mathematical equations, the physical theorist proceeds to show how he can predict innumerable facts previously out of his range by use of this arbitrary *ad hoc* machinery. The process involved somehow reminds me of a record sea voyage made through a fog!

The fact remains, however, that the recent development of quantum mechanics forms one of the most astounding and important chapters of all theoretical physics. It is interesting to recall how this great advance came about through the faith of the German physicist Planck at the outset of the present century. His direct experience with the phenomena of radiation had led him to believe that there were discontinuous processes at work, not to be explained by any modification of the time-worn classical theories, and so he was led to formulate his celebrated quantum hypothesis in 1900. It was this daring concept of Planck, more than anything else, that has freed the minds of physicists from the shackles of too conventional thinking about atomic phenomena, and so has made possible the quantum-mechanical quest, of which the end is not yet in sight.

There has always been an abundance of faith among the physicists. Everyone knows how Newton and others have found confirmation even for their religious beliefs in the lawful character of physical phenomena. It is not hard to understand why the tendency towards dogmatic affirmation among the physicists has been stronger than among the mathematicians. For the physicist, with considerable justice, feels that he is exploring the mysteries of the only actual and very exciting universe; whereas the mathematician often appears to live in a purely mental world of his own artificial construction. A good illustration of this tendency of the physicists is afforded by their changing attitudes towards the wave theory versus the corpuscular theory of light. Over a considerable period the corpuscular theory of Newton held sway; then this was displaced by the wave theory of Huygens, the Dutch physicist; and nowadays a kind of vague, uncertain union of the two is generally accepted.

In this connexion it is especially interesting to recall the scientific beliefs to which Faraday was led in his fundamental work on electricity and magnetism. From his experimental results in this field, he saw that there was obeyed here as elsewhere the law which he called the 'conservation of force' and which we to-day would call the 'conservation of energy'. He saw that this energy was localized in space, and he could only conceive of it as being propagated in time; and so he was led to the belief that electromagnetic energy is also propagated with finite velocity. Thus in an article, "On the Conservation of Force," published in 1857, he expressed himself as follows: "The progress of the strict science of modern times has tended more and more to produce the conviction that 'force [energy] can neither be created nor destroyed' . . ."; "*time* is growing up daily into importance as an element in the exercise of force; to inquire, therefore, whether power acting either at sensible or insensible distances always acts in *time* is not to be metaphysical." By way of justification of the rather mathematical direction in these thoughts, Faraday said further, "I do not perceive that a mathematical mind, simply as such, has any advantage over an equally acute mind not mathematical . . ."; "it could not of itself discover dynamical electricity nor electromagnetism nor even magneto-electricity, or even suggest them." But the achievements of the more mathematical Maxwell were later to show that Faraday had underestimated the power of pure reason.

It is thus clear that through an act of faith Faraday attained to a kind of deeper insight; for the existence of the electromagnetic wave has long since been established experimentally. However, the beliefs of Faraday in this connexion cannot be regarded as absolutely true, since according to present-day conceptions the notion of energy which he accepted is only roughly valid as a statistical approximation. Nevertheless, Faraday certainly penetrated more into the nature of electrical and magnetic phenomena than any of his contemporaries; and it is difficult to see how, with the limited mathematical and physical knowledge at his disposal, he could have gone any further in the way of prophetic conjecture.

The intimate relation between philosophical-

scientific points of view and actual advances in theoretical physics has been admirably illustrated by Einstein's gravitational theory of 1915. Taking as his starting point the bold but reasonable hypotheses that matter must condition space and time, and that, in parts of space remote from matter, elementary particles move with uniform velocity in a straight line, he arrived at his field equations as the most elegant mathematical embodiment of these ideas. Thus there was obtained a quasi-geometrical theory of gravitation which in certain respects is more natural than the celebrated theory of Newton, while the predicted differences, although excessively minute, are in favour of the new theory. But Einstein's theory cannot be regarded as true in any absolute sense since it gives us at best a partial, highly idealized view of the physical universe.

It is scarcely too much to say that, since the beginning of the present century, the main advances in theoretical physics have been the outcome of a similar kind of mathematical guesswork, in which, however, the mathematician himself has taken little or no part! The guessing of the physical theorist is guided almost entirely by considerations of subtle mathematical analogy.

In my own limited experience in mathematical physics I have seen how natural it is to take a positive attitude on open questions. Thus a good many years ago I showed mathematically that mere spatial symmetry about a centre necessitates a *static* gravitational field. This led me to believe that the Einstein field equations were probably too inelastic to fit the facts, but I did not put forth this opinion. Shortly afterwards Lemaître, in trying to explain the expanding (non-static) stellar universe, found it necessary to modify the field equations, in part because of my result; and so my belief was to this extent justified.

Again, I have had during the last few years a feeling that a conceptual space-time model for quantum mechanics is likely to be found, although theoretical physicists would in general disagree. Nevertheless, this faith is so strong that my recent researches lie principally in this direction. I have already found interesting results, and feel confident that these efforts will not be wasted, since the possibilities of the conceptual approach need to be more carefully explored.

In ending these remarks about the role of intuition, reason, and particularly of faith, at the physical level, it is to be remarked that the physicist as such systematically ignores the phenomena of life, for it is inorganic and not living matter with which he concerns himself in his laboratory.

All in all, it is a faith in the uniformity of Nature which remains the guiding star of the physicist, just as for the mathematician it is a faith in the self-consistency of all mathematical abstractions, although these faiths are more sophisticated than ever before.

Intuition in the Biological Field

Although I have no especial acquaintance with the biological, psychological or social domains, it seems clear to me that a similar situation prevails in them. In the biological field the intuitions upon which one depends are those associated with the concept of the organism and its evolution. These intuitions cannot be formulated conclusively and completely in simple postulates, as is possible at the mathematical and physical levels. It is rather through an acquaintance with an immense array of interrelated, analogous facts that the biologist finds himself able to deal with novel situations. By means of the geological record on one hand, and the results obtained in the field and laboratory on the other, he acquires a better and better understanding. His principal weapon is always inductive reasoning. It seems certain that a deductive treatment of biology is at least very remote, and if ever accomplished will be utterly different from anything which we can imagine to-day. There are, however, a few special fields like the theory of heredity, in which a considerable mathematical structure has been developed. In this theory, by means of the chromosomes and their corresponding abstract genes, it has been possible to explain a complicated array of facts.

The faith of the biologist generally tends in the direction of a mechanistic theory of life or of some opposing vitalistic theory. In fact, he is forced to employ the principle of physical causation in his efforts to understand biological phenomena and does not yet know of definite limitations in its use. Recently there has been some indication of a return to vitalism, so that once more a considerable group of biologists are convinced that not all the phenomena of living matter are to be accounted for by ordinary physical and chemical law. The controversy involved has long been a burning one, and accordingly one naturally suspects that the question is really meaningless. In any event, however, special mechanistic

hypotheses have so far pointed the way to new creative advances.

It is interesting to remark that the insufficiency of a rigorously deterministic theory of the living organism admits almost of mathematical demonstration in the following manner. A genuinely mechanistic universe would have to be free of any infinite factors. For example, if one accepts a simple Newtonian theory, there might be reaching the earth from infinite space unknown quantities of matter and energy, so as to change arbitrarily the course of events upon the earth. But in any completely mechanistic system, free of such infinite factors, it is not difficult to prove that there will necessarily be a kind of eternal Nietzschean recurrence. For example, we are here together this evening considering a particular topic. The strict adherence to the deterministic point of view would entail the consequence that in the eons yet to come this same scene will be re-enacted infinitely often. I submit that this is dramatically improbable!

Recent advances in the chemical knowledge of large organic molecules seem to indicate an innate hospitality of actual matter toward the evolution of the living organism. In this way a plausible genetic account of the origin of life is suggested, which, however, can scarcely be called mechanistic. It begins to seem possible that we are on the verge of further refinements in our concept of matter, such as Emerson anticipated in the quotation made above.

The situation at the psychological level is even less amenable to precise treatment. All of us have a lifelong experience with ourselves and other human beings. This automatically gives rise to a vast complex of intuitive psychological notions. We all are aware of course that there are concomitant physiological processes going on in the body, nervous system and brain. Now it is the business of the professional psychologist to give exact definition and interpretation to these crude ideas; and he finds his greatest illumination in the facts of abnormal psychology, with which most of us are unacquainted. However, in the case of either layman or professional, the processes of reasoning are mainly by analogy. Even the psychiatrist, familiar with many concrete cases, must treat each new patient by the inductive method. There are too many psychological intuitions and too few exact laws for any imposing edifice of pure reason to be erected.

In certain restricted psychological domains, formalization is to some extent possible. Thus I have ventured to formulate a theory of 'æsthetic measure', by explicit numeration and weighting of æsthetic factors. This aims to explain certain simple æsthetic facts in our enjoyment of visual and auditory forms. The theory has been to some extent substantiated by experiments made at Harvard and elsewhere. But in any event, no matter how successful the theory might prove, it would be wholly absurd to try to set up an elaborate logical structure on the basis of the fairly arbitrary and inexact assumptions involved. Generally speaking, as we proceed from the more objective to the more subjective levels of thought, we find that elaborate logical structures seem to be of less and less utility.

The basic belief of the professional psychologist is in the completeness of the physiological accompaniment of every psychical fact; and he formalizes the observed facts by means of this parallelism. But there is a conflict between this attitude of the technician towards mind, for whom the individual is a complex of neurally characterized components, and that of the ordinary man—equally an expert though of a different kind—who sees all sorts of permanent values in personality, not adequately characterized in neural terms. The second attitude leads nearly all of us to have deep affections and abiding personal loyalties, whether or not we are psychologists!

Here again I think that these apparently opposing points of view are both more or less true; and I incline all the more to this opinion because of my conviction that as yet we know relatively little about the phenomena of personality. For it seems certain to me that the extent of hidden organization in our universe is infinite, outside as well as inside space and time; such a conviction is very natural to a mathematician, since the three ordinary spatial dimensions and the single temporal dimension are for him only particular instances of infinitely many other conceivable dimensions! If this be true, any broad conclusions concerning the nature of personality would seem altogether premature.

At the social level the most serviceable intuitive ideas cluster around the concept of societal evolution. It is of course the comparative study of human institutions which furnishes the principal interest. The analogy between forms of society and evolving organisms is a deep-lying one. Here again the useful logical structure which can be built around the very complicated facts is exceedingly

simple. Even in such a formalized field as ethics, dealing with the behaviour of the individual as a member of society, logic takes an almost negligible role.

Belief here seems to gather principally around the idea of societal progress. Progress—or its non-existence—serves as our fundamental tenet. Some believe that society can improve indefinitely, tending toward a perfect society. Such a belief is of course a fundamental one in most religious systems. Others find this idea too naive. They stress the gregarious instinct in man and tend to think of societal changes as taking place in various directions strongly conditioned by changing physical environment. All would admit, however, that without the concept of dynamical social processes, social theorizing would be stale and unprofitable.

Science and Society

Let us turn now to consider some further conclusions, towards which this brief survey of intuition, reason and faith at the various levels seems to point.

So far as intuition and reason are concerned, these are the common property of all competent individuals. The narrow, closely articulated chains of deductive reasoning serviceable at the earlier levels are more and more replaced by loose webs of inductive reasoning at the later levels, as we pass from the objective to the subjective. At the same time the basic intuitions change from the simple and precise types employed in mathematics and physics to the increasingly complicated and diverse forms characteristic of biological, psychological and social phenomena.

However, it is just as necessary to clarify and to formalize our knowledge at these later levels as at the simpler ones. The processes of systematic reasoning, whether inductive or deductive, have always a definite prophylactic value, and in particular enable us to avoid the dangers of prejudiced and intolerant points of view. It may be observed in passing that the careful application of impartial thoroughgoing analysis is as important for everyday living as it is in the study and the laboratory.

The striving for rational comprehension is one of the noblest attributes of man. In his age-long difficult struggle he has been able to secure greater freedom only through a better technical mastery of his environment. No other method of liberation has been vouchsafed to him. But this increased mastery has brought with it automatically new intellectual responsibilities and a more complex way of life. In consequence, unforeseen and threatening dangers arise from time to time; and there is thus imposed on him the necessity to advance still farther, which is to-day more urgent than ever before. A new injunction has been laid upon the spirit of man, to know and to understand ever more broadly and deeply.

Now along with the increase in scientific knowledge there appear certain crudely expressed, deeper insights, not completely true or false, some in opposition to others, but all supremely valuable, nevertheless. These are embodied in beliefs which seem the inevitable accompaniment of all creative thought.

Thus in the daring effort of the scientist to extend knowledge as far as possible, there arises an aura of faith. It is this spontaneous faith which furnishes the most powerful incentive and is the best guide to further progress.

Such are some of the very general points of view to which a considerable mathematical and scientific experience has led me. If they are worthy of serious attention it is not because of their novelty, but rather because in their aggregate they rise above the details of the numerous specialized fields of knowledge and sustain the scientist in his unceasing and ardent search after truth.

Doubtless many will be ready to ask the ever more insistent question: If science has thus profoundly modified the general outlook and way of life of mankind, is it not the especial duty of such an association as ours to point out constructive remedies for the ensuing maladjustments? In "Part II; Science and Warfare" of his admirable address as president of the British Association last August, Lord Rayleigh closed by expressing the hope that our two associations could co-operate in such a way as to "bear useful if modest fruit in promoting international amity". In this hope all of us will deeply concur. The presence of Sir Richard Gregory among us at this meeting is the first token of the projected closer relations between the parent British Association and ourselves. It is much to be desired that this action will encourage further unification of the whole scientific world. I am sure that practically all our joint membership would agree with me that it is the wider diffusion of "the steady light of scientific truth" which holds out most hope of a better understanding among men.

Religion in Science*

By Sir Richard Gregory, Bart., F.R.S.

IF religion be understood in the broadest sense as the belief in spiritual being, it may be said that prolonged inquiry has failed to show any authenticated instance of a people, however backward, who do not hold to some form of belief which, though vague and rudimentary, can be deemed religious. It is difficult to draw a hard and fast line between magic and religion; and indeed it is a question whether such a differentiation is essential from the point of view of the inquirer who is attempting to trace the development of the religious idea. For even 'magic' implies some form of spiritual influence humanly directed. Belief in the efficacy of magic is as much an act of faith in some form of spiritual action as the Christian belief in Divine intervention in human affairs; and the essence of a religious belief is that it is an act of faith.

Faith may be defined as a belief which is not dependent upon material evidence or logical demonstration from premises ultimately based upon sensory phenomena (although such phenomena may be invoked to support faith as 'proof'); but it acquires its validity from some general scheme or theory of the nature and purpose of 'being', 'life', the universe, or, as the philosopher would say, of 'the Absolute', or, to use a popular phrase, 'the scheme of things'. In essence it is emotional: not rational. In its contact with 'facts', faith interprets them not by observation and experiment—that is by the approach of reason and science, which demand proof in the strict logical sense, by reference to phenomena—but it evaluates them by the test of coherence with its theory of life and the universe. Such a scheme need not necessarily be consciously formulated or even realized as a whole. Probably, in the early phases of development, such realization rarely, if ever, takes place, as the minds of backward peoples work concretely and are averse from abstraction.

Whatever may be thought of evolutionary faith, evidence from comparative study shows that there is, in the mentality of man, a generalized urge towards a belief in spiritual values underlying the material appearances of the universe. This urge is fundamental. Various influences such as the influence of geographical and cultural environment, and possibly mental differences of racial strains, if there are such, have combined to produce the different types of belief and the religious systems which have been followed, or are now followed, by mankind. It is at least significant that in the so-called primitive religions of the less advanced cultures there should be such strikingly close similarities in ritual and belief as have been recorded by the anthropologist. Further, when we try to attain an objective view of the more advanced religions, it is no less striking that they fall into a more or less uniform pattern in regard to the relation of the three elements—tradition, ritual and ethics; in other words, in the relation of belief to worship and the conduct of life. Dissension arises not so much out of the nature of tradition as when interpretation is added to it and made a test of orthodoxy. When there is a difference in the central objects of the various cults, opportunities for dissension are multiplied and reconciliation might seem wellnigh impossible.

Religion and Life

Many reasons have been put forward to account for the origin of religion, but it cannot be said that any of them has solved the problem. Ancestor-worship, ghost-propitiation, worship of the soul, belief in spiritual beings, reverence for tribal leaders, and other causes, have all been suggested as originating causes of religious sentiment. Primitive man had no religion, except such as was embodied in a system of social virtues. Men possessing these virtues to a high degree, and using them to make the tribe powerful or conditions of life more pleasant, would be esteemed as benefactors or heroes not only during life but also after death, and this veneration would develop into ancestor worship and later into soul worship.

If it is assumed that the Divine purpose of the existence and evolution of life upon the earth is that man should work out his own salvation, it is difficult to understand what the ultimate gain will be when the earth will no longer be in a condition to maintain life as we conceive of it. All that science can say as to the future of the earth or any other planet or system in the astronomical universe, is expressed in the words of the hymn "Our little systems have their day: they have their day and cease to be". We may contemplate the progressive development of man and society to whatever stage may satisfy our ideals, but, so far as we now know, the whole phantasmagoria will eventually

* From a public lecture delivered before the American Association for the Advancement of Science meeting at Richmond, Va., on December 27 1938.

be dissolved, and the death of mankind will be the final penalty for achieving the highest type conceived by the human mind. This thought should not, however, be subversive of effort and aspiration on the part of humanity as a whole, any more than the individual should neglect noble motive and conduct because he himself has to pass away whether his influence has been for good or evil. Though science is unable to provide any positive evidence for survival of personality after death, it must acknowledge that belief in such survival is a powerful ethical factor in human development.

Evidence of the progressive development of forms of life in the past, and of changes still going on, is so convincing that it may almost be regarded as a law of Nature. In so far, therefore, as evolution signifies an orderly succession of organic growth, few would venture to deny the fact; but how and why such changes are brought about has not yet been established beyond discussion. Whether organic evolution has proceeded by gradual development of small variations of structure and habits, or by the sudden appearance of new forms, is a question for naturalists to decide among themselves in their search for natural causes. The court of observational science is concerned only with evidence which throws light upon such causes and effects without assuming the existence of supernatural design or intervention. Whether behind the natural causes producing evolution there is a transcendental principle or architect is not the concern of naturalists, but of other philosophers. Their position is that even if the facts of organic evolution cannot be explained by existing knowledge, they will be explicable when more is known about natural causes and consequences, without introducing a *deus ex machina* to conceal our ignorance and suppress the pursuit of objective evidence.

We have passed the stage when, in order to afford support for Christian belief in general, and the Mosaic account of creation in particular, it was only necessary to find naturalistic or rationalistic explanations of miraculous and other elements in Biblical records. Such attempts to fit all new knowledge into a system of thought having no claims to scientific accuracy or intention served no useful purpose to the Bible or to science, and to-day would satisfy neither historical students nor naturalists. A much sounder basis can be found by applying evolutionary principles to religious thought, and by studying sacred books as stages in the story of man's progressive discovery in theology. It is only by disregarding history that the idea of a fixed and final theology becomes possible. In science, there are no final interpretations or unchangeable hypotheses; and if the same principle were recognized in theology, religion would share some of the vitality of the natural sciences. Evolution can be regarded by the theologian as merely the means of creation; and this conception of gradual development is not incompatible with Christian theology. It is through the acceptance of the idea of evolution in the spirit as well as in the body of man that the partition which formerly separated religion and science is being dissolved.

All religions—primitive and advanced—include ethical ideals relating to human conduct and its supreme end. The highest form of religious ethic is that in which the aim of conduct is complete and implicit obedience to a code which is conceived as the will of God. In the less generous manifestations, this obedience may be rendered against natural inclination as an outcome of fear; for "Fear of the Lord is the beginning of wisdom." It may then degenerate into a formalism as lifeless, and even more harsh, than that of those systems which stress ceremonial purity. On the other hand, it may become a joyous and spontaneous acceptance of a mode of life, such as it is conceived would be consonant with the nature of God, subject to such limitations of the flesh as are ineradicable—the idea of saintliness. Hence arises the desire for uprightness as an end in itself, either with a view to reward, if not in this world, in another; or pursued selflessly for its own sake. This concept of religious ethic, which rests ultimately on personal and intimate relationship between the individual soul and its God, has led to the highest idealism in human conduct; but it has also degenerated into many unpleasant forms of exaggerated and distorted continence and self-torture in the monastic, ascetic and mystic conceptions of the holy life.

Science and Social Ethics

In recent years, there has been much discussion of the ethical or social consequences of the application of mechanical and other scientific discoveries to industry. In the early days of the industrial revolution in England, there was little of the scientific spirit in industry. The discoveries of science were used with as much indifference to science as to humanity. The inventions of the eighteenth and early nineteenth centuries came from the workshop rather than from the scientific laboratory. Machines were devised and operations developed largely by trial and error methods, and academic research had few points of contact with industrial practice. The characteristic of the present age is the utilization in industry of principles, properties, and products revealed by scientific research, whether carried on solely in the pursuit of knowledge or with a practical purpose in mind.

It is sometimes suggested that progressive science and invention are responsible for the troubled condition of the world at the present time, owing largely to over-production. It would be just as reasonable to blame the Almighty for good harvests, or for providing in some parts of the world all the means of existence for primitive man without the need for labour. The fault is not with those who create gifts for men's comfort and enjoyment, but with the social system which prevents their easy distribution and use.

Material progress must be more striking, more patent to observation than is man's ethical and social development; and it is also no more than to be expected that there should be a lag in the latter. It was more than a generation after the initial movement of the industrial revolution in Britain that progress in other directions began to affect the population of the country at large. To anyone who takes long views and compares conditions of to-day with those of a hundred to a hundred and fifty years ago, it must appear a rash statement which characterizes man's progress in that period as one of command over the material resources of the world only. This is to deny certain patent facts. For example, in every department of human life—at any rate, in Great Britain—there has been in that period a stupendous awakening to a sense of social responsibility—a very real development in man's mentality and the growth of society. In effect, it now demands that the latest results of all branches of scientific research, but more especially of those affecting hygiene, both physical and mental, should be applied to the conditions of life of the population as a whole. This is not philanthropy or religion as such in the narrow sense, but arises from a broadening in the conception of the relations and obligations of man to man.

Apart from the mental and moral effect, difficult to gauge, of improved conditions of life, the increased application of the results of scientific research to those conditions has been accompanied by a parallel growth in the sense of responsibility in the community towards every member of that community—the concept that of the wealth of the community a toll must be taken to ensure that from the cradle to the grave each individual member shall be ensured a certain measure of healthy nourishment, opportunity for growth in body and adequate instruction in mind by education to become a useful member of the community, with assurance of medical attention in employment, of a measure of sustenance to the unemployed and of provision for old age.

This is not communism, unless it be communism to admit that I am my brother's keeper; but it is precisely towards this admission that practical application of the modern science of man is directing mankind, both as an inference from the study of societies of the past and the humbler societies of to-day among primitive peoples, as well as from a diagnosis of the elements which appear to make for progress in modern civilization. It is true that a modern society with a sense of responsibility, but which, it must be admitted, we have not yet fully attained, is only now approaching the position of the primitive group in its sense of responsibility to its members; but the advance, the spiritual progression, lies in the range of that sense of responsibility. Whereas in the primitive form it embraces the members of the blood kin only, or those of the local group within which the members are more or less intimately acquainted, within a modern society it may reach out to embrace all members of a great nation, and possibly, when warring creeds agree to sink their differences, it may extend to all men of good will, to whom the dignity of man as an individual entity transcends racial and political boundaries. When, if ever, that comes to pass, it will be possible to gauge how far man has advanced along the road of ethical as well as material progress.

To many, the way seems long to go. The urge of nationalism and its ideals has diverted the thoughts of peoples—both Fascist and Communist—away from the main stream of human progress into narrower channels in which rocks and rapids threaten at every turn to shipwreck all that is best in civilization. The result is that instead of science having to save modern civilization from being overwhelmed by barbarous hordes, it seems to have provided the means of self-destruction. Man has advanced so little in spiritual evolution that he is just as much a barbarian in his use of aerial bombs and poison gas as he was when his weapons were only clubs and arrows.

Such prostitution of the rich gifts with which modern science has endowed the human race must be condemned by all who see, in the general feelings of civilized people to-day, incipient stages in the development of characteristics which distinguish man from other living creatures. The law of the jungle is that of the battle to the strong, and the race to the swift. It recognizes no right to live except by might; destroys the weak; has no sympathy with suffering; and no sense of the highest human values. In the struggle for existence, man has survived because his physical structure and intelligence have enabled him, individually and in communities, to master the things which would destroy him. His social instincts have at the same time been extended from the family to the tribe, the nation and the empire, and will reach their highest and best when they embrace the world.

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that their names may be registered, and at the same time enclosing a remittance of one guinea, which will cover fifty telephone inquiries.

Association of Women Science Teachers

THE annual meeting of the Association of Women Science Teachers was held at Bedford College, London, on January 4 and 5. At the evening meeting, Prof. Allan Ferguson, lecturing on eighteenth century physics, stressed the value of the research of that century's Gargantuans in science, some interesting points of detail not always being known to present-day teachers. At the morning session, the Joint Standing Committee with the Association of Assistant Mistresses (Science Panel) presented its recent General Science Examination Syllabus, containing the maximum of content and topic for examination in general science after a five-year course to school certificate standard in girls' schools. Copies of this syllabus can be obtained on application to the Hon. General Secretary. A discussion was held on new methods of biology teaching, emphasizing practical problems with living organisms. Both plants and animals were discussed. It appeared there is less need for the keeping of animals in the school, except occasionally, when the biology is taught from the functional view-point and with reference specially to the mammal. Discussion ensued as to whether there may be consequent application or lack of it, in the pupil's mind, to man. The study of the characteristics of living things based upon exact observational work on plants and animals in school appears to present more practical difficulties in the keeping of living creatures in captivity. Opportunities for visiting a glass factory and a precious metals refinery were welcomed by members. It is announced that the Association proposes to devote a whole day's discussion on March 4, in London, to the Science Masters' Association General Science Report and to the Spens Report in its bearing upon science in the curriculum.

Chinese Red Cross and Chinese Universities

MRS. HALDANE, who has recently returned to London after a visit to China, writes as follows: "I paid a visit to the training centre established by the Chinese Red Cross Medical Commission. This Centre is under the direction of Dr. Robert Lim, formerly professor of physiology in the National University of Peiping. Dr. Lim has temporarily given up his scientific work and has taken in charge the reorganization and extension of the Chinese Red Cross. . . . In Kunming, formerly known as Yunnan Fu, I had the pleasure of meeting President Chiang, formerly of the National University of Peiping, and his staff; and also President Mei of Tsing Hua University, Peiping, and his colleagues. . . . Premises have been placed at the disposal of the universities by the Yunnan Provincial Government, but although they still have remnants of their former libraries, there is an almost complete dearth of equipment, scientific instruments and other material. The two Presidents and the professors of pure and applied engineering and biology informed me that they would be deeply grateful if their colleagues in Europe could send them copies of current periodicals, such as the *Proceedings of the Royal Society*, the *Journal of Physiology* and *Biochemical Journal*, physical and engineering journals, etc. If members of the various scientific societies in Great Britain would care to assist either the Chinese Red Cross Society, or Prof. Chiang and Prof. Mei and their staffs, I should be most grateful if they would communicate with me, c/o The China Campaign Committee, Parliament Mansions, Orchard Street, S.W.1. The Committee would be glad to make arrangements to forward either periodicals or money, and to put British scientific or university circles in touch with their Chinese colleagues who at present so badly need their moral encouragement and active assistance."

Earth Tremor at Quetta

ON January 6 at 4h. 43m. (Madras Time), an earth tremor of considerable intensity shook Quetta, in Baluchistan. The shock was of short duration and no damage or casualties are reported. It will be remembered that this district is liable to be visited fairly frequently by earthquakes and that it was visited by a particularly strong one on May 31, 1935, of duration about 30 seconds and having an epicentral tract 68 miles long and 16 miles wide in a direction S. 15° W. from Baleli. The epicentre was stated by Sen and Bakshi to be lat. 30·5 N., long. 66·5° E., and although the intensity was 10 on the Rossi-Forel scale, road and rail communications were not interrupted, nor was the supply of electric current, so that the intensity was not so great as at Assam in 1897, Kangar in 1905, or Bihar in 1934. No fault movement was apparent at the surface, and as the intensity fell off rapidly from the central region, the focal depth was assumed to be shallow. On that occasion, Kalat, Mastung, several villages and Quetta itself were completely destroyed, and Quetta was sealed for a considerable period owing to the extreme difficulty of the rescue work. The death roll was estimated at 15,000–20,000. The buildings of the new Quetta are of reinforced concrete and brick, and some attention has been paid to earthquake-proof design. They have withstood well the shocks of September and October 1937 and the present earthquake.

Roads and Traffic

IN his presidential address on "Roads and Traffic" to the Junior Institution of Engineers on December 9, Sir Charles Bressey raised many interesting questions the answers to which are not easily found out. He says, for example, that deductions from the most careful traffic observations are apt to be stultified, at any rate in a free country like Great Britain, by the essential fluidity and waywardness of traffic. The installation of traffic lights may lead drivers to make use of hitherto unfrequented side roads, so as to avoid the signals. These vagaries vitiate comparisons, and are particularly disconcerting in

London, where so many alternative streets are available for an intelligent driver. In addition, the science of mechanical engineering advances so rapidly that steep road gradients which render a road unpopular at present may in ten years time offer practically no hindrance to a motor-car. Any attempt to replan an ancient capital must be largely empirical; opportunism must play a leading part. The inertia of habit is a powerful force. Theoretical considerations have to be tempered by common sense based on a general knowledge of London's development and of the improvements which have been carried out or rejected during past years. However carefully the flow of traffic be recorded, we are still at a loss to account for the underlying causes of the waywardness. The mysterious flittings of trade and industry influence the distribution of the nation's population. The advantages of undeviating directness over great distances, unhesitatingly accepted by the Roman road engineers, who were untrammelled by county boundaries and ring fences around estates, would not be accepted implicitly to-day.

Archæological Discoveries on Monte Alban, Mexico

EXCAVATION of the Mixteco-Zapotecan necropolis on Monte Alban, near Oaxaca, Mexico, which has been in progress under the direction of Dr. Alfonso Caso without interruption since 1932, has produced a remarkable assemblage of objects, ornamental and ceremonial, in gold, semi-precious stone, or other material, illustrating the religion, life and customs of these peoples. In large measure the remarkable character of the finds justifies the dictum of the excavator that in the archæological sense this is the most important region in the whole of the Americas, not even excepting the Peruvian site of Cuzco. When one hundred and two tombs had been explored, the site was visited in the course of the past year by General L. Cardenas, President of the Republic. The occasion was marked by the opening of three further tombs, which the President, accompanied by Señor Caso, was the first to enter. The first tomb offered little calling for comment, but the second and third afforded the unexpectedly important and spectacular discovery of series of vivid polychrome frescoes adorning the walls. These depict gods and their symbols, as well as priests in ceremonial garb, sacred and mythological motives, and ritualistic symbols of life and death. In the third tomb, painted figurines were standing in ritual niches, and on the floor was a skeleton, obviously of a great chief, surrounded by a number of funerary objects, axes and knives in obsidian and flint, a green jade statuette of Quetzalcoatl, the Plumed Serpent of the Zapotecs, and a number of domestic and liturgical vessels. The mural decoration is considered to be the most important discovery yet made on Monte Alban. The President was so strongly impressed by the importance of the excavation that not only did he promise a Government subvention in order that the work might be continued, but also ordered an immediate grant of 10,000 piastres (approximately 60,000 francs). A brief account of the discovery and of the frescoes and contents of the tombs by Dr. Nuñez y Dominguez, secretary of the National Museum of Mexico, has recently appeared (*J. Soc. des Americanistes*, N.S., 29, 2).

Insects of Cambridgeshire

A LIMITED number of copies of the "Zoology of Cambridgeshire", the major part of which is occupied by the account of the Insecta, are now available. They are reprinted from the "Victoria County History of Cambridgeshire and the Isle of Ely", vol. 1, pp. 77–245 (1938), reviewed elsewhere in this issue (p. 46). Applications for these reprints, accompanied by a remittance of £1 1*s*., which covers postage, should be made to the editor, Dr. A. D. Imms, Zoological Laboratory, Cambridge.

Announcements

DR. R. L. SMITH-ROSE has been appointed, as from January 1, superintendent of the Radio Department of the National Physical Laboratory, which includes the Radio Research Station at Slough in addition to the section of the Department at Teddington. Dr. Smith-Rose has been principal scientific officer-in-charge of the Departments ince Mr. Watson Watt left the Laboratory in 1936 to take up a position in the Air Ministry.

A BIBLIOGRAPHY on the housing and equipment of school libraries, compiled by Ellen L. Anderson, has been issued by the Office of Education, United States Department of the Interior. The bibliography consists of an annotated and selected list of references intended to show what schools have done for their libraries and to give concrete suggestions to those interested in starting a school library or in improving an old one. The list is limited to the physical aspects of the library and administration.

IN NATURE of December 24, p. 1130, in an article on "Future Developments in Coal Treatment and Utilization", reference was made to a paper by Prof. A. C. G. Egerton and to experimental work described by Mr. Armstrong. Mr. Armstrong was said to be a research student from South Africa. We are informed that this is incorrect; Mr. Armstrong is from New Zealand.

THE National Research Council of Canada, Ottawa, announces the forthcoming publication in book form of a scientific account of a comprehensive study on the effect of sulphur dioxide on vegetation. The book covers an investigation carried out under the auspices of the National Research Council during the period 1929–38 on the effect on vegetation in Northern Stevens County, Washington, of sulphur dioxide from the large metallurgical plant at Trail, B.C., and also elaborate experiments planned to elucidate the many questions which arose in connexion with the investigation.

ERRATUM.—NATURE, January 7, p. 34, article entitled "Structure of Proteins", col. 2, paragraph 2, last line, for "marked" read "masked".

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 80.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Patterson Diagrams in Crystal Analysis

LETTERS on the interpretation of Patterson Fourier syntheses (vector maps) have recently appeared in NATURE[1,2,3]. Is not the claim made or implied in these letters, that a new method of interpretation has been discovered, due to a misapprehension concerning the existing methods of crystal analysis?

What may be termed the classical method of crystal analysis, which has successfully elucidated numerous structures, is briefly as follows. Observations are made of the intensities of a number of X-ray spectra or reflections from crystal planes. The unit cell and symmetry scheme of the crystal is determined, and the composition and density of the crystal indicate the number of atoms of each kind in the unit cell. The efficiency with which the individual atoms scatter X-rays through various angles can be deduced from the known distribution of electron density around each atomic centre. The investigator then has the problem of adjusting the positions of the atoms in the unit cell until he hits on an arrangement which explains the intensities of the observed spectra. The atomic positions are fixed by a finite number of co-ordinates (parameters) and it is his task to assign values to these parameters. Given a sufficiently extensive set of observations of intensities, no reasonable doubt can be entertained that a solution which explains these observations is unique.

In the second paragraph of his letter[3], Prof. E. H. Neville outlines an argument which purports to demonstrate that substantial reconstruction of the crystal structure is theoretically impossible, since the observations may correspond to an infinity of solutions, and then proceeds to combat this view. I do not know from what source he got the impression that such a view has ever been expressed or could possibly be held by anyone who is acquainted with the methods of crystal analysis. If the distribution of scattering matter within the unit cell could have any general form, the problem would of course be indeterminate; but in actual fact we know the scattering matter to be clustered in a characteristic way around a finite number of atomic centres; this makes the solution unique. This has been the basis of crystal analysis for the last twenty-five years, and is so well known that it is generally taken for granted and not specifically referred to in recent work, which perhaps explains how Prof. Neville's misapprehension has arisen.

The elegant Fourier series methods now so widely used have been summarized in the recent letters, and need only be very briefly outlined here. The distribution of scattering matter in the crystal cell may be represented by the sum of a three-dimensional Fourier series. X-ray measurements determine the amplitudes of the terms of this series, but not the phases. Hence the observations do not lead directly to a solution by straightforward Fourier summation. The problem is simplified by the fact that in most cases one is dealing with a projection of the structure which has centres of symmetry. In such a case the uncertainty of phase reduces to one of plus or minus sign, since each term must have a crest or a trough at each centre of symmetry. A common method of procedure is to get by trial and error a first approximation to the structure which decides the signs of the more important Fourier terms, and then by summing the Fourier series with these terms to get a better idea of the atomic distribution, which enables more signs in turn to be fixed. Two or three such stages of approximation complete the structural determination. In special cases, other methods of fixing the signs can be used. The basis of this procedure is again our knowledge that the scattering matter is concentrated around a finite number of atomic centres as explained above.

The Patterson synthesis[4] or vector map does not demand a knowledge of phases, because the coefficients of its Fourier series are proportional to measured intensities, not amplitudes. The density in a Patterson projection at the end of a vector drawn from the origin represents the integration over the unit cell of the product of densities at all pairs of points in the crystal structure which have that vector relationship. Patterson sections can also be constructed.

Since a Patterson diagram can be directly constructed from the observations and summarizes all the measurements in a graphic way, it has certain very attractive features. It is a comparatively novel method, and it is highly important to explore ways of using it to deduce the crystal structure. Papers by Beevers and Schwartz[5], Lipson[6], Gaskell[7], Goodwin and Hardy[8] and Wells[9] may be quoted as examples where it has already been successfully employed. In most of these cases there are certain outstandingly heavy atoms in the crystal structure, and the relative positions of these atoms can be deduced from the positions of peaks in the Patterson diagram. These heavy atoms are so important in fixing the signs of the Fourier terms that the analysis can then be completed. The 'geometrical method' proposed by Wrinch, which Prof. Neville claims "has opened a new chapter in crystal analysis", is essentially the same as that used in these and other investigations.

Experience with Patterson diagrams brings home to one, however, the very great difficulty of interpreting them owing to their complexity. Dr. Wrinch gives an example[2] of the relation between point diagram and vector diagram to show how the first can be deduced from the second, but the idealized case she takes is so extremely simple that any method of analysis would immediately succeed. If we compare the density distribution (point diagram) and

Patterson (vector diagram) for a moderately complex case such as an aromatic molecule, it is quite difficult to trace the relationship even when the structure has been determined and we know the answer to the problem set by the Patterson. Not only the relative positions within the molecule, but also those of atoms in neighbouring molecules related by the symmetry elements, are represented by superimposed diffuse peaks in the Patterson, and these combine in such a way that it is extremely hard to unravel the tangle.

The molecule of a protein such as insulin, for which Crowfoot[10] gives Patterson diagrams, is of a much higher order of complexity than an aromatic molecule containing a few benzene rings; it is far beyond anything as yet analysed by X-rays. Experience with the difficulty of interpreting the Patterson of simpler molecules warns us to be extremely cautious in basing conclusions upon the diagram of insulin. I would not venture to suggest that analysis is a hopeless task; on the contrary, there is every hope of ultimate success, for aromatic molecules seemed hopeless problems not many years ago, and their analysis is now almost a matter of routine. I would plead, however, for a due sense of proportion. Langmuir and Wrinch claim that the main features of the Crowfoot diagram can be explained by a certain concentration of scattering matter in a simple way at a few typical points in the molecule. If this claim is substantiated, it affords a useful hint as to one possible solution; but whether it is unique depends, as in all cases of X-ray analysis, on the justification for the assumptions which are made. In simple structures, we are on sure ground, for we know the scattering units to be a finite number of atoms. In a protein, the assumptions must as yet be vague and provisional. Exaggerated claims as to the novelty of the geometrical method of approach and the certainty with which a proposed detailed model is confirmed are only too likely, at this stage, to bring discredit upon the patient work which has placed the analysis of simpler structures upon a sure foundation.

W. L. BRAGG.

Cavendish Laboratory,
Cambridge.
Jan. 4.

[1] NATURE, **142**, 581 (1938).
[2] NATURE, **142**, 585 (1938).
[3] NATURE, **142**, 994 (1938).
[4] *Phys. Rev.*, **46**, 372 (1934).
[5] *Z. Krist.*, **91**, 157 (1935).
[6] *Proc. Roy. Soc.*, A, **156**, 462 (1936).
[7] *Z. Krist.*, **96**, 203 (1937).
[8] *Proc. Roy. Soc.*, A, **164**, 369 (1938).
[9] *Proc. Roy. Soc.*, A, **167**, 169 (1938).
[10] *Proc. Roy. Soc.*, A, **164**, 580 (1938).

Vector Maps and the Cyclol Hypothesis

IN recent issues of NATURE, letters have appeared in which claims of a new method of analysis of Patterson vector diagrams are put forward with particular reference to those of crystalline insulin[1]. Substantially this method is not new to crystallographers; it is implied in Patterson's original paper in 1934[2], has been used in a number of published analyses[3], and has been taught to students in Cambridge for the past three years.

What is new, however, is the use of certain additional assumptions and their application to cases where they are of extremely dubious validity. Thus the substitution, suggested in Prof. E. H. Neville's letter, of points for peaks in the Patterson vector map, and the subsequent attempt to find a point system to which this vector map corresponds, is not a reliable procedure in the analysis of complex crystals. The maxima in the vector map can only be assumed to correspond in position to steps between regions for which the electronic density ρ is a maximum if the maxima of ρ are sharp and the vectors between them are distinguishably different. While these conditions hold for simple structures where each peak stands for one atom, they cannot be assumed to do so for compounds as complicated as the proteins and here, therefore, much greater caution would seem to be required. Even if, however, we make this simplifying assumption and are prepared to treat as a geometrical point a group which we know to be composed of some hundred atoms, far greater ambiguity exists than might be imagined from reading Dr. D. M. Wrinch's papers[4].

In analysing the insulin structure on the basis of the X-ray evidence, there are two possible courses of procedure; that of discovering the maximum information that can be deduced from the position and relative intensity of the peaks on the Patterson diagram; and that of building an *a priori* model structure and attempting with it to account for the observed pattern. The first method, which I have described in a recent discussion on protein structure and which will be published in detail elsewhere, leads to a family of solutions obtainable by attributing different weights to the seven symmetrically distinct points in a hexagonal packing of two layers. A large number of these give no worse fits than the particular case which Dr. Wrinch claims as the unique solution. None of them, however, gives a complete fit, and to discriminate between them would appear, for lack of further experimental evidence, to present considerable difficulties.

The second method is one often employed in crystal analysis, but until now only for relatively simple structures. Its likelihood of success depends very largely on the possibility of selecting on the basis of chemical knowledge a structure which has a finite probability of being near to the true one. In the case of the protein this task is one of enormous difficulty, but Dr. Wrinch claims to have accomplished it with her cyclol cage model. In judging its *a priori* plausibility, two features need to be borne in mind; first, that it involves the assumption of a four-linked instead of a two-linked amino acid residue, for which no chemical evidence has been put forward and which, as Prof. Bergman[5] and Dr Neuburger[6] have pointed out, is open to grave objections on chemical grounds; secondly, that it is only one arrangement, though admittedly a simple and symmetrical one, out of the multiple possibilities of arrangements of such four-linked residues. Nevertheless, if the proposed structure were found to account for the X-ray data, Dr. Wrinch would have a *prima facie* case for its acceptance.

To what extent, however, does it account for the X-ray data? Vector maps of Dr. Wrinch's hypothetical cyclol structure bear no resemblance to those which have been derived by Miss Crowfoot from her observations[7]. The distribution of atoms in the cyclol skeleton is far too continuous to give rise to any definite peaks, and no distribution of side chains can do other than increase the blurring of the picture. Dr. Wrinch has not however used the vector map of

the cyclol skeleton. Instead of this, she has chosen certain density concentrations, which are treated as positive and negative point scattering centres, for the construction of the vector diagrams. It is difficult to see on what principle in relation to the structure these centres have been chosen. Two of the strongest of them are completely arbitrary and another is attributed to a zinc atom the 28 electrons of which would scarcely seem effective scattering centres in a molecule with 20,000 electrons.

Even if the selected points led to the observed Patterson diagram, this would not prove the correctness of the cyclol structure, as the characteristic pattern is not involved in deriving them. At the most it would show that the cyclol model had been a useful working hypothesis for arriving at a structure based on scattering centres which might have very different physical structure. It is, however, certain that it does not do so. Out of the possible 3,600 vectors between scattering centres which this model would provide for the vector map, only thirteen are published in Dr. Wrinch's paper, but the selection is almost completely arbitrary as it contains vectors corresponding to weak pairs of scattering centres while many corresponding to strong pairs are omitted. It is stated that this omission makes no difference to the general agreement with the observed vector maps; but this is demonstrably incorrect, for a basal projection using *all* the vectors from the stronger scattering centres shows a pattern in which all resemblance with the observed vector map has vanished.

In view of this, it can fairly be claimed that the scattering centre model derived from the cyclol hypothesis fails completely to account for the X-ray evidence for insulin, and further that the cyclol model itself leads to results incompatible with that evidence. In rejecting it, therefore, it is not necessary, however desirable, to put forward another model—the problem still remains an open one. Such a result is disappointing, but the discussion to which this attempt has given rise will not be wasted if it focuses attention on the need for an active collaboration of physicists and chemists in a concentrated attack on the structure of the protein molecule.

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Dec. 21.

[1] NATURE, **142**, 955 (1938).
[2] *Phys. Rev.*, **46**, 372 (1934). *Z. Kryst.*, **90**, 517 (1935).
[3] For example, Fankuchen, I., *Z. Kryst.*, A, **94**, 212 (1936). Gaskell, T. F., *Z. Kryst.*, A, **96**, 203 (1937). Wells, A. F., *Proc. Roy. Soc.*, A, **167**, 169 (1938).
[4] Wrinch and Langmuir, *J. Amer. Chem. Soc.*, **60**, 2274 (1938). Langmuir and Wrinch, NATURE, **142**, 581 (1938).
[5] "Annual Review of Biochemistry" (1937).
[6] Royal Society Discussion on Protein Structure, November 1938.
[7] Crowfoot, *Proc. Roy. Soc.*, A, **164**, 580 (1938).

Vector Maps and Heavy Atoms in Crystal Analysis and the Insulin Structure

CONSIDERABLE discussion has recently been devoted to the use of vector maps in crystal analysis[1] based on the Patterson method[2]. Although much use has been made of this method in the insulin structure[1,3] the complexity of the problem and the inadequacy of the existing X-ray data to yield a solution in terms of atomic positions do not appear to have been sufficiently emphasized. It is quite obvious that fifty-nine relative measurements of amplitude cannot define a structure consisting of several thousand atoms. So far as these measurements go, the structure is effectively a continuous distribution of scattering matter, and every arbitrary assignment of phase constants to the amplitudes will yield a solution. As individual atoms cannot appear in any of these solutions, there does not seem to be any rigid criterion in favour of one any more than another. The Patterson maps, which summarize the X-ray measurements, do not remove this ambiguity because, for a similar reason, we do not know what meaning to attach to the peaks in these maps. The suggestion that certain concentrations of atoms in the molecule can be treated as point scattering sources does not seem to constitute even a reasonable approximation. As no large gaps between the atoms are likely, it may also be very difficult to distinguish between regions of high and low density which are due to real features in the structure, and those which are due to unavoidable deficiencies in the series representing it.

The situation must be sharply contrasted with that of the more simple organic molecules, containing up to about forty atoms, which have been successfully analysed by the X-ray method. In these, the number of observed amplitudes is always very much greater than the number of co-ordinates defining the positions of the atoms, and an exact solution becomes feasible. It is accepted if it outlines the number of separate atoms required by chemical analysis, and if each of these atoms shows its expected scattering power for X-rays.

Even in these relatively simple organic structures (20–40 atoms), the Patterson method has not so far proved very helpful, in spite of its great power and usefulness where only a few atoms are concerned[4]. This is partly due to the difficulty of analysing structures where all the atoms (except hydrogen) have nearly the same scattering power for X-rays. A vast number of inter-atomic vectors results, all nearly equally important, while those which are prominent are frequently due to chance concurrences.

For many organic structures, a more powerful method of attack is available, and has recently been extensively developed and studied[5,6]. By chemical methods a heavy atom can often be inserted in an organic molecule the structure of which has to be determined. Co-ordinated complexes with metal atoms are sometimes easy to make, and with unsaturated compounds, alcohols, acids and certain weak bases, it is in general possible to insert a heavy halogen.

Stated very briefly, the effect of an atom of high scattering power in a complex structure is to translate the unknown phase differences of the X-ray reflections into differences of amplitude which can be measured. In terms of the Patterson method, the vectors between the light atoms become unimportant, and we obtain only the vectors connecting the heavy atom to each of the light atoms—in other words, we get the actual structure directly, instead of its vector representation.

The method must be adjusted to particular cases. When several heavy atoms are involved, their relative positions may be deduced from a preliminary Patterson analysis. With an origin related to these atoms, a subsequent analysis employing the phase constants due to these atoms may then reveal the finer detail. In an isomorphous series, still better results may be obtained from the differential effect of substituting successively heavier atoms[5,6].

One very important point is that the swamping effect of a heavy atom on the contributions from the

lighter atoms does not depend very much on the size of the molecule, or the number of these lighter atoms, provided that (as is generally the case for organic molecular structures) there is no definite integral relationship between such intra-molecular periodicities as may exist and the cell dimensions of the crystal. As the molecule gets larger, the geometrical structure factors on the average depart further from their possible maxima. The contributions from the various atoms tend to cancel each other out, and we are left with a small residual. This is, in fact, one of the essential difficulties in analysing a complex structure by trial. A comparatively small change in the structure may mean a big change in these small residuals. But the contribution from the heavy atom is constant and will continue to dominate the situation. In a recent example[6], a nickel atom, representing only about 10 per cent of the total molecular weight, was found to determine practically all the phase constants.

It may be going too far to suggest that the insulin structure could be determined in this way. The molecule does, however, contain a few zinc atoms, and if these could be replaced by mercury, as has been suggested, a very profitable study might ensue. Of course there are formidable difficulties. If the reflections are swamped in the manner described, much greater accuracy is required in the intensity determinations to reveal the small differences. In the same way, a higher numerical accuracy is required in the calculations to reveal the minor maxima and differentiate them from spurious effects. Recent results have shown that these difficulties can be overcome in a moderately complex molecular structure[7].

J. MONTEATH ROBERTSON.

Davy Faraday Laboratory,
Royal Institution, London, W.1.
Dec. 28.

[1] Langmuir and Wrinch, NATURE, 142, 581 (1938); Wrinch, NATURE, 142, 955 (1938); Neville, NATURE, 142, 994 (1938).
[2] Patterson, *Z. Krist.*, 90, 517 (1935).
[3] Crowfoot, *Proc. Roy. Soc.*, A, 164, 580 (1938).
[4] Harker, *J. Chem. Phys.*, 4, 381 (1936); Llewellyn, Cox and Goodwin, *J. Chem. Soc.*, 883 (1937).
[5] Robertson, *J. Chem. Soc.*, 615 (1935); 1195 (1936).
[6] Robertson and Woodward, *J. Chem. Soc.*, 219 (1937).
[7] Robertson and Woodward, *J. Chem. Soc.*, (1939, in preparation).

A Temperature Effect in Laue Photographs

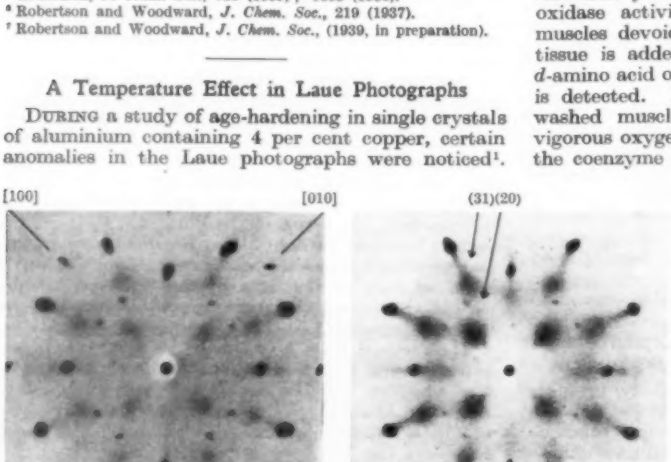
DURING a study of age-hardening in single crystals of aluminium containing 4 per cent copper, certain anomalies in the Laue photographs were noticed[1]. Some of these were associated with the progress of hardening, but others appeared to be due to another cause. Further investigation showed the presence on the Laue photographs of single crystals of aluminium, of certain faint streaks also observed in photographs of the alloy. When photographed at 550° C., the intensity of these streaks or ill-defined spots greatly increased. Similar effects were observed in sodium chloride and magnesium oxide. The effect observed in sodium chloride at room temperature has already been noted by Wadlund[2], and an explanation of its origin given by Zachariasen[3]. The fact that the effect becomes much more intense when the temperature is raised suggests that it is due to thermal vibrations of the lattice. In diamond at 500° C. a faint effect similar to that obtained with the other crystals is present, although little is to be seen at room temperature.

The photographs reproduced herewith illustrate the effect in aluminium. The X-ray beam is parallel to (001) and (110) is vertical; they were taken with a silver target with 60 kv. peak on the tube. The intense spots near the centre are largely due to the silver characteristic radiation, and have also been recorded with monochromatic radiation yielding a 'cross grating' pattern in which the spots have indexes (20) and (31).

G. D. PRESTON.

Metallurgy Department,
National Physical Laboratory,
Teddington, Middlesex.
Dec. 8.

[1] NATURE, 142, 569 (1938).
[2] *Phys. Rev.*, 53, 843 (1938).
[3] *Phys. Rev.*, 53, 844 (1938).



Aluminium at 20° C. Aluminiumat 550° C.

Flavo-Protein of the Heart Muscle Tissue

I HAVE shown previously[1] that the coenzyme of the *d*-amino-acid oxidase is present not only in liver and kidney tissues, which exhibit the *d*-amino acid oxidase activity, but also in skeletal and heart muscles devoid of this enzyme. If washed muscle tissue is added to the alanine test (coenzyme-*free* *d*-amino acid oxidase and alanine), no oxygen uptake is detected. If, however, the extract of a boiled washed muscle suspension is added to the test, vigorous oxygen uptake takes place. It is clear that the coenzyme of the *d*-amino acid oxidase, a flavin compound, is present in a bound form, probably as the prosthetic group of a hitherto unknown enzyme.

When cytochrome oxidase is prepared according to the method of Keilin and Hartree[2], it is found that the flavin nucleotide follows the cytochrome oxidase and the group of insoluble dehydrogenases. I have now found that a flavo-protein can be extracted from such muscle preparations by the action of dilute alcohol and salt solution. Following this extraction, the flavo-protein has been gradually purified to a flavin phosphate content of 0·65 per cent. This new flavo-protein can be regarded as practically pure,

considering that 0·7 per cent of flavin phosphate found by Haas[3] in his flavo-protein from yeast is the highest flavin content so far obtained.

The new flavo-protein is readily soluble in distilled water, giving a greenish yellow solution. The prosthetic group can replace quantitatively the coenzyme of the *d*-amino-acid oxidase and is considered to be the same compound.

The details of the purification will be given elsewhere.

F. B. STRAUB.

Molteno Institute,
University of Cambridge.
Dec. 6.

[1] Straub, F. B., NATURE, **141**, 603 (1938).
[2] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **125**, 171 (1938).
[3] Haas, E., *Biochem. Z.*, **298**, 378 (1938).

Sulphanilamides and Rabies

HITHERTO, chemotherapy has seldom been successful in virus diseases, but the use of sulphanilamides in lymphogranuloma inguinale[1], choriomeningitis[2], and trachoma[3] has opened new possibilities in this field during the past year. There is, so far, no record of experimental work giving favourable results in the chemotherapy of rabies, however, and from an observation in Khartoum, the sulphanilamides appear to have no effect in this condition.

Four rabbits, of approximately equal size and weight, were infected subdurally with an emulsion of fixed virus (Paris strain), and three of these were given 1 c.c. Prontosil Soluble daily by the intravenous route for the following six days. The fourth was kept as a control, although this virus has never failed in Khartoum to produce paralytic rabies in six to seven days during numerous passages through sheep and rabbits since 1935, when it was obtained from the Public Health Laboratories in Jerusalem. By the seventh day all four rabbits were moribund, with typical signs of paralytic rabies, and were killed. No difference could be observed between the treated animals and the control, either in the incubation period or in any other feature of the disease.

R. KIRK.

Stack Medical Research Laboratories,
Khartoum,
Anglo-Egyptian Sudan.
Dec. 13.

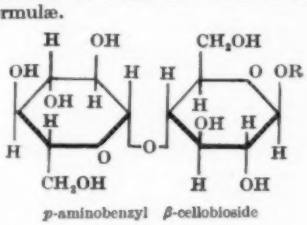
[1] MacCallum, R. O., and Findlay, G. M., *Lancet*, 136 (1938).
[2] Neal, J. B., *J. Amer. Med. Assoc.*, **3**, 1353 (1938).
[3] Kirk, R., McKelvie, A. R., and Hussein, H. A., *Lancet*, 904 (1938).

Immunity to Experimental Pneumococcus Infection with an Artificial Antigen

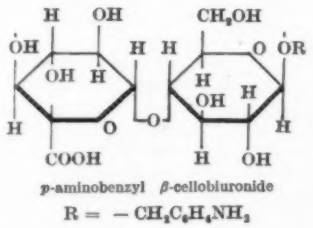
FOR the past few years, we have been engaged in this laboratory in studying the factors which govern the immunological specificity of carbohydrates. This problem has been approached by an investigation of the chemical structure of the specific bacterial polysaccharides themselves and by a study of the immunological properties of artificial antigens prepared by combining the aminophenol or benzyl glycosides of saccharides of known structure with protein. The latter method has been of particular value in revealing certain of the fundamental factors which govern the specificity of carbohydrates. The stereochemical configuration of simple hexoses[1], the configuration of intramolecular linkages of disaccharides and the position of such linkages[2] are all-important determinants in orienting the specificities of these saccharides. More recently it has been found that the conversion of the primary alcohol group of a hexose to the carboxyl group likewise alters the immunological properties of artificial antigens containing the hexoses, as opposed to those containing the hexose uronic acids[3].

Although antigens containing the hexose-uronic acids possess certain of the serological characteristics of the specific pneumococcus polysaccharides, for they precipitate in high dilutions in anti-pneumococcal horse sera of various types, it has as yet not been possible to produce anti-pneumococcal immunity by injecting animals with the glucuronic and galacturonic acid antigens. The reason probably is due to the fact that the hexose uronic acids do not approximate closely enough in structure to the more complex building stones of certain of the pneumococcus polysaccharides, the aldobionic acids. These observations have led to the belief that in order to evoke anti-pneumococcal immunity in experimental animals with an artificial antigen, it is not necessary to have as the immuno-specific group a long-chained type specific polysaccharide, but that a simpler saccharide, the pattern unit from which the polysaccharide is constituted, should suffice.

An artificial antigen has therefore been prepared by combining the diazonium derivative of the *p*-amino benzyl glycoside of cellobiuronic acid, the aldobionic acid from which the Type III pneumococcus polysaccharide is constituted[4], with horse serum globulin[5]. For purposes of comparison, a similar antigen containing the corresponding glycoside of cellobiose has also been prepared. The chemical structure of the cellobioside and cellobiuronide is identical save for the grouping occupying the 12th position, as can be seen from the accompanying graphic formulæ.



p-aminobenzyl *β*-cellobioside



p-aminobenzyl *β*-cellobiuronide

R = $-CH_2C_6H_4NH_2$

This difference in chemical structure suffices, however, to confer on each antigen containing the glycosides vastly different immunological properties. The sera of rabbits injected with the cellobiuronic antigen precipitate the Type III pneumococcus specific polysaccharide, agglutinate Type III pneumococci, and produce a typical swelling of the capsule when living Type III organisms are mixed with the anti-serum.

Furthermore, the cellobiuronic acid antisera confer passive protection on mice against infection with virulent Types II, III and VIII pneumococci. The animals injected with the artificial cellobiuronic acid antigen acquire active resistance to infection with virulent Type III pneumococci as well. The sera of rabbits injected with the cellobiose antigen, on the other hand, exhibit none of these phenomena, nor are the rabbits themselves resistant to Type III pneumococcal infections.

These experiments demonstrate that cellobiuronic acid has an important immunochemical function in determining the immunological properties of Types II, III and VIII pneumococci. It is apparent, furthermore, that antibacterial immunity can be evoked by injecting experimental animals with an artificial antigen containing as the immuno specific group the pattern unit of the polysaccharide rather than the intact carbohydrate itself. The results of these experimental studies have brought forth still a new and important principle. Whereas an antigen containing the complex bacterial carbohydrate of Type III pneumococcus gives rise to antibodies which are type specific[6], those elicited by the antigen containing the pattern unit, or aldobionic acid, exhibit broader specificity and afford passive protection in mice against infection with Types II and VIII pneumococci as well.

In 1936, I described at the Second International Congress for Microbiology in London the synthesis of two aldobionic acids, acaciabiuronic and gentiobiuronic acids[7]. Whether these synthetic saccharides, when combined with protein, will evoke antibacterial immunity in experimental animals is a problem under investigation at the present time.

WALTHER F. GOEBEL.

Hospital of the Rockefeller Institute
for Medical Research,
New York.
Nov. 21.

[1] Goebel, W. F., and Avery, O. T., *J. Exp. Med.*, **50**, 521, 533 (1929).
[2] Goebel, W. F., Avery, O. T., and Babers, F. H., *J. Exp. Med.*, **60**, 599 (1934).
[3] Goebel, W. F., *J. Exp. Med.*, **63**, 29 (1936); Goebel, W. F., and Hotchkiss, R. D., *J. Exp. Med.*, **66**, 191 (1937).
[4] Heidelberger, M., and Goebel, W. F., *J. Biol. Chem.*, **70**, 613 (1926); Hotchkiss, R. D., and Goebel, W. F., *J. Biol. Chem.*, **121**, 195 (1937).
[5] Goebel, W. F., *J. Exp. Med.*, **68**, 469 (1938).
[6] Avery, O. T., and Goebel, W. F., *J. Exp. Med.*, **54**, 437 (1931).
[7] Report of Proceedings, Second International Congress for Microbiology, London, 1937, p. 424; Hotchkiss, R. D., and Goebel, W. F., *J. Biol. Chem.*, **115**, 285 (1936); Goebel, W. F., and Reeves, R. E., *J. Biol. Chem.* (1938).

Chromosomes of *Cimex*

THE conclusions drawn from the numbers of chromosomes found during spermatogenesis in *Cimex spp.*[1] require considerable modification as a result of the examination of further material. New evidence of the nature of the variable elements and of their numerical range has given a different aspect to the problem.

In three wild populations of *C. lectularius*, including the type previously considered to be a sub-species[1], 13 autosome pairs are constantly present and behave normally, also observed by Darlington[2]. They divide reductionally at the first meiotic division and equationally at the second, forming an equatorial ring at metaphase. Within the ring lies a group of elements which have divided equationally at the first division. Variation in chromosome number is due to variation within this group. A continuous series of modal values from 6 to 16 has been found in different individuals, with a maximum deviation from the mode of $\pm$ 3 in any one individual.

This central group contains the sex chromosomes, one of which, distinguished by its shape, staining capacity and position, is present in every second metaphase complement. From the frequent secondary pairing of this chromosome with two others of the central group, I am of the opinion that the male *C. lectularius* has an *XXY* sex mechanism. Comparison with the karyo-type of *C. rotundatus* supports this view, for in this species all the nuclei which have been examined invariably showed 14 pairs of autosomes and three sex chromosomes, with no other central elements.

(*a*) (*b*)

SECOND METAPHASE FIGURES OF (*a*) *C. lectularius*, (*b*) *C. rotundatus*.

In *C. lectularius* the variations in chromosome number that have been observed seem to be due to unequal division at first anaphase and unequal segregation at second anaphase of a group of inert chromosomes, possibly related to the sex chromosomes. The first division results in variation of chromosome complements in the same individual, the second division produces variations between individuals. From counts of two nuclei there is evidence that the female possesses a similar chromosome constitution. These phenomena I intend to analyse in greater detail in a future publication.

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Zoology Department,
University of Glasgow.
Dec. 2.

[1] Slack, H. D., NATURE, **142**, 358 (1938).
[2] Darlington, C. D., unpublished.

Irritant Exudation from a Centipede

MR. E. BURTT'S experience[1] with the East African millipede *Spirobolus* reminds me of an incident with the Melanesian centipede, *Scolopendra*, in the Solomon Islands.

An individual about seven inches in length was picked up with a pair of entomological forceps, care being taken to see that none of the poison from the large mandibles reached the skin. Some of the twenty or so pairs of legs did touch my hand, as a consequence of which the back of the hand had a painful numbness for the rest of that evening and during the same night. Although this irritation was clearly not comparable in intensity with that caused by the

repugnatorial glands of the millipede, it seems worth recording, as F. G. Sinclair[2] refers only to the mandibular poison in the Chilopoda, which would seem to have, at least in the genus *Scolopendra*, a strong irritant in the paired appendages.

R. A. LEVER.

Suva,
Fiji.
Nov. 28.

[1] NATURE, 142, 796 (1938).
[2] "Cambridge Natural History", vol. 5 (1895).

Soil Erosion in England

DURING the past few years, the possibilities of soil erosion in Great Britain have been in question owing to the immense loss of good farmland in large areas of the United States, Canada, and many tropical countries as the result of the exhaustive systems of farming carried on during past years. The very heavy rainfall of exceptional intensity on two days this autumn in Devon has enabled us to obtain some idea of the possible intensity of soil erosion under the systems of cultivation of south-west England.

On August 4, 3·90 in. of rain were recorded at Totnes between 2.30 a.m. and 9 a.m. G.M.T., and on November 26, 1·24 in. were recorded between 6.15 p.m. and 7.35 p.m. G.M.T. and a further 1·67 in. between 11 p.m. (26) and 9 a.m. (27) G.M.T. The exact duration of the second storm is not known, although it probably lasted only about 1½ hours. Robinson[1] states that the rate of erosion of soil by running water depends principally on four factors, namely: (1) the amount and intensity of the rainfall; (2) the angle of slope; (3) the presence or absence of a vegetative cover, and, if present, its character; and (4) the nature of the soil itself. Under the conditions experienced in Devon, sheet erosion alone took place on most slopes up to about 1 in 10, while no gully erosion was found on slopes of less than about 1 in 6. The amount of possible erosion was restricted owing to the high proportion of grassland in this part of the country. Very good protection was also given by thick and high cover crops, such as wheat, oats and marrow-stem kale. Even a thin covering of weeds afforded quite good protection from erosion; but root crops gave little or none, and even appeared in some places to encourage gullying.

Severe gullying occurred on farms on the fringe of Dartmoor, while the most marked instances of soil erosion off the Moor were found on the red conglomerate soils derived from Permian breccia in the Paignton district and on a dark soil derived from Middle Devonian shales and tuffs.

The work of Bennett in the United States[2] tends to show that soils the clay fractions of which have high SiO_2/R_2O_3 ratios are erosive, and that there is a critical ratio at 2. The SiO_2/R_2O_3 ratios of the clay fractions of the surface horizons of the two Devon soils mentioned are 1·98 and 1·90 respectively. The average ratio for most of the cultivated surface soils in Devon is about 1·6, which tends to show that most of them have been eroded in past times and have now settled down under cultivation to a comparatively stable condition, as have those of North Wales, where the climate is very similar to that in south Devon[3]. The recent observations, however, seem to show that this state is due largely to the type of agriculture practised in the region, and that a return to predominantly arable conditions in the hilly country might result in the impoverishment of soils by erosion.

J. B. E. PATTERSON.

The Laboratory,
Dartington Hall Trustees,
Totnes, S. Devon.
Dec. 15.

[1] Robinson, G. W., "Soils: Their Origin, Constitution and Classification" (Second edition. Murby 1936) p. 68.
[2] Bennett, H. H., *Soil Sci.*, **21**, 349 (1926).
[3] Robinson, G. W., *J. Agric. Sci.*, **20**, 618 (1930).

A School of Whale Sharks in the Bahama Islands

FOR years I had received newspaper clippings and second-hand verbal recitals of whale sharks seen off the west side of the Bahamas. Much effort was made to verify these, but for a long time I had no evidence of scientific value. However, in July 1936, there came to me authentic data concerning a specimen seen off Bimini, and shortly thereafter I published a faunal record for *Rhineodon* in the Bahamas[1].

In my studies of the distribution of the whale shark, I have long had the aid of the U.S. Hydrographic Office. It has asked ships' officers for reports of their observations all over the world of this great shark. These reports can be very definitely made because of the great size of the shark, its broad head and terminal mouth, and the chequer-board arrangement of bars and spots on the sides makes its identification easy. The latest report to the Hydrographic Office was from Mr. E. R. Fenimore Johnson of Camden, New Jersey, U.S.A.

On June 3, 1938, Mr. Johnson, in his ketch *Elsie Fenimore*, ran into a school of about twelve whale sharks in lat. 24° 32′ N. and long. 77° 37′ W., about four miles east of Sugar Cay, in the "Tongue of the Ocean". The school was under observation for nearly an hour and, the sea being fairly smooth and the sharks close to the boat, Mr. Johnson made careful notes of the behaviour of the fish and took some 200 ft. of moving-picture film of various individuals as they swam around the vessel.

Being without fear, these sharks swam so close to the boat that "We could easily have jumped astride their backs"—an observation which parallels Dr. William Beebe's off Cape San Lucas, Lower California. Mr. Johnson adds, "We ran into one fish, but he did not seem greatly upset, and his efforts to get clear were quite sluggish". This also is what has been reported by many others. The fish has no enemies, and is not afraid of a man or a boat.

The school was made up of a dozen individuals ranging in length from about 18 ft. to about 31 ft. The school had no formation, but was spread out irregularly over an area of about a quarter of a mile square. The fish did not seem to be going anywhere, and an individual shark would swim over a small area and would turn and go over it again as if hunting for something. Mr. Johnson courteously loaned me the film showing this behaviour. Close study of it convinced me that the fish were feeding by swimming about with their wide terminal mouths partly open. When asked about this, Mr. Johnson gave me definite information.

These were engaged in feeding. A fish would swim for an interval of one or two minutes with its mouth open and with its upper jaw about even with the

surface of the water. It always had its dorsal fin and the upper lobe of its tail fin well out of water. Then the fish would dive to a shallow depth for a short interval and would come to the surface and repeat the manœuvre. The water was examined by naked eye, but was found to contain only scattered jelly fish about 15 mm. in diameter.

I have long conjectured that *Rhineodon* feeds by swimming at the surface of the water with open mouth, that small organisms are strained out by the sieve-like gill structures and that the water passes out through the gill-openings. Mr. Johnson is fortunate in being the first observer to witness this manner of feeding and to photograph the fish in the act.

E. W. GUDGER.
American Museum of Natural History,
New York.
Nov. 29.

[1] *Science*, **84**, 227 (1936).

Sound Absorption of Snow

THE impressive and all-pervading quietness following a fall of snow is a commonplace experience, though, so far as we are aware, no measurements of the sound absorption of snow have been published. The recent cold spell provided a suitable opportunity to make such measurements in the reverberation chamber of the National Physical Laboratory.

Two specimens of freshly fallen snow were tested, each measuring 10 feet square, one approximately 1 inch thick, the other approximately 4 inches thick. The measurements were necessarily conducted somewhat hurriedly, and the results which are given in the accompanying table for various frequencies from 125 to 4000 cycles per second (that is, virtually the speech range), can only be approximate.

Thickness of snow	Absorption coefficients for the following frequencies :					
	125	50	500	1000	2000	4000
1 inch ..	0·15	0·40	0·65	0·75	0·80	0·85
4 ,, ..	0·45	0·75	0·90	0·95	0·95	0·95

It will be seen that freshly fallen snow is highly absorbent, its effectiveness being equalled by few known materials of corresponding thickness. In particular, a 4-inch layer absorbs as much as 90 per cent or more of the intensity of medium and high-pitched notes; and greater thicknesses would no doubt present equally striking figures for low-pitched notes. Thus, apart from the muting of impact noises, the 'deadening' effect of a layer of snow can be well understood.

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Points from Foregoing Letters

PROF. W. L. BRAGG discusses the recent communications by Dr. D. Wrinch and Prof. E. H. Neville in which it is claimed that a new method of interpreting the Patterson X-ray diagrams enables the identification of the structure of the insulin molecule. He points out that the method suggested is essentially the same as that previously used by several investigators, but the assumption that the insulin diagram can be explained by a certain concentration of scattering matter in a simple way at a few typical points in the molecule, appears risky.

Writing on the same subject, Prof. J. D. Bernal criticizes the suggestion of Prof. Neville that points may be substituted for peaks in the Patterson vector map. He claims that the scattering centre model derived from the cyclol hypothesis fails completely to account for the X-ray evidence for insulin and that the cyclol model itself leads to results incompatible with that evidence.

Finally, Dr. J. M. Robertson considers that fifty-nine relative measurements of amplitude cannot define a structure consisting of several thousand atoms; he suggests that by the introduction of heavier mercury atoms in place of the zinc atoms present in the insulin molecule it may be possible to obtain diagrams that would throw some light on the structure of the molecule.

Photographs of Laue X-ray diffraction patterns obtained with aluminium at 20° and 550° C. are submitted by G. D. Preston. Certain spots and streaks which are only faintly marked at 20°, become considerably intensified at 550°, and the author considers that the effect is to be attributed to the thermal agitation of the crystal lattice.

A flavo-protein extracted from the heart muscle tissue with dilute alcohol and salt solution is found by Dr. F. B. Straub to contain 0·65 per cent of flavin phosphate. Its non-protein group can replace quantitatively the co-enzyme of the *d*-amino-acid oxidase and is probably the same compound.

An artificial antigen which, when injected into rabbits, yields sera that agglutinate Type III pneumococci, has been prepared by Dr. W. F. Goebel by combining the diazonium derivative of the *p*-amino benzyl glucoside of cellobiuronic acid with horse serum globulin. The cellobiuronic acid antisera confer passive protection on mice against virulent Types II, III and VIII pneumococci.

New evidence of numerical variation in the chromosomes of *Cimex* spp. and of the nature of the variable elements has led Dr. H. D. Slack to modify his former concept of the polyploid origin of the genus, since the different numbers form a continuous series derived from the irregular distribution of a specialized group of chromosomes.

R. A. Lever writes that contact with some of the legs of the melanesian centipede, *Scolopendra*, produced numbness of the back of the hand, so it appears that the irritant exudation already referred to by Mr. Burtt is not confined to the mandibles.

Observations following upon two heavy rainfalls, in August and November, in Devon, show, according to J. B. E. Patterson, that gully erosion takes place on slopes greater than 1 in 6 and that sheet erosion occurs on most slopes up to 1 in 10. Weeds afford quite good protection from erosion but root crops appear to give little or none.

Research Items

Stone Age Culture from Kenya Colony

A STONE age culture, for which the name 'Kombewa culture' is suggested from the name of the locality in which it occurs, is described by the Venerable Archdeacon W. E. Owen in *Man* of December 1938. Kombewa is the name of a subsection of the Location of Seme in the Central Kavirondo District of the Nyanza Province, Kenya Colony. It lies about halfway up the escarpment on the north of the Kavirondo Gulf and about eight miles from it. Between 1932 and 1938, four workshop sites were discovered, and single specimens have been found over a wide area. Three sites were hill-top sites and showed no stratification, but stratified rubbles, carrying both rolled and unrolled hand-axes of Acheulean type, flakes and cores, were found at Aringo and Ng'ira in Karungu on the east coast of Lake Victoria, and subsequent search revealed the fourth workshop site on the slopes of Nyandwat Hill, near Ng'ira. The raw material in every instance is the local rock, large, medium or small flakes being struck from a selected block. In the majority of instances care had been taken to prepare the area from which the butt of the flake tool was removed, so that many tools show a faceted or trimmed butt. The peculiarity of the tool is its perfectly plain upper surface. The struck cores are classified under four heads with reference to the butt area into natural butts, faceted butts with central ridge, faceted butts with trimmed ridge, and rounded butts. The majority of cores show only one tool removed. Finished tools are small in number compared with cores. The outline is approximately rectangular with rounded corners, ovate and nearly round to semicircular. The butts are generally as wide as the widest part of the flake. Some of the cores seem to have been used as scrapers. One large flake seems to have been a chopper, and two hammer stones were found. The suggested date is Middle Stone Age; but at the present stage it suffices to remember that at Ng'ira specimens occur in a horizon carrying rolled and unrolled Acheulean tools.

Formation of Pronephric Duct

Two views have been put forward regarding the method of formation of the pronephric duct in the urodele Amphibia. First, that it is produced by a backward growth from the pronephric rudiment, and secondly that it is a composite structure resulting from the fusion of a series of segmental units. By means of *intra vitam* staining with Nile blue sulphate and by means of operative interference, R. J. O'Connor has thrown light on this problem (*J. Anat.*, Oct. 1938). The types chosen were *Ambystoma tigrinum* and *Triton tæniatus*. It was shown that when the caudal end of the rudiment of the duct is stained and then development allowed to proceed, the stain is carried on by the growing rudiment right down to the cloaca in the walls of the duct when formed. Also that if a piece of some other tissue is interposed caudal to the end of the rudiment, it prevents the backward extension of the rudiment and so prevents the formation of a pronephric duct. From this, it is concluded that the duct is developed from a backward extension of the pronephric rudiment.

New Type of Hereditary Behaviour in Fishes

Mollienisia is a genus of cyprinodont fishes. *M. sphenops* occurs around the Gulf of Mexico from Florida to northern Mexico. *M. latipinna* is found in southern Mexico and Central America. Where these species overlap is found an intermediate form known as *M. formosa*, which is evidently of hybrid origin but occurs exclusively as females. This peculiar situation has been investigated by Mr. Henry Meyer (*J. Genetics*, **36**, No. 3). When *M. formosa* is mated to either species, the offspring are all females of maternal type. But this is not parthenogenesis, since unmated females produce no young. The two species and the laboratory hybrid between them all had 36 chromosomes, and nuclear size suggests that the *M. formosa* females are also diploid. There was no differential death-rate either before or after the birth of the young which would account for the absence of males. There is no tendency to hermaphroditism, and sex reversal is improbable. To account for the purely matroclinous inheritance, the following explanation is suggested. The eggs of *M. formosa* are fertilized by the other two species, but the paternal chromosomes remain inactive in the foreign cytoplasm. In maturation of the eggs of the hybrids, the paternal chromosomes are all eliminated into the polar body. This condition is compared with meiosis in *Œnothera* hybrids and in the homopteran *Pseudococcus nipæ*. Further cytological investigation should settle whether this explanation is correct.

Double-grafted Apple Trees

THE ancient problem of the reciprocal influence of scion and stock is further complicated by the increasing use in various parts of the world of fruit trees with two or more graft unions and composed of more than two varieties. Trees are frequently built up *ab initio* with a third variety used as an intermediate stem piece between stock and scion, whilst it is a common practice with established trees to graft shoots of a new variety on to the framework branches of an existing scion. M. C. Vyvyan (*J. Pom. and Hort. Sci.*, **16**, 251; 1938) has investigated the effect on a given scion of stock varieties used both as rootstock and intermediate stem piece. The scion was always Stirling Castle, the stocks and intermediate pieces being *M* IX and *M* XII combined in all four possible ways, namely, XII/XII, IX/XII, XII/IX and IX/IX. The trees of type XII/XII were largest and those of type IX/IX the smallest. IX/XII trees, that is IX as intermediate and XII as rootstock, were intermediate in size, whilst XII/IX trees were only slightly larger than IX/IX trees. Trees with vigorous (XII) root systems or intermediate pieces produced more wood growth and fewer fruit buds per metre of wood than those with dwarfing (IX) root systems or intermediates, and in this respect the root system tended to have a greater influence than the intermediate piece. Swellings at some of the graft unions indicated that obstruction at the union may be in part responsible for some of the effects observed, but it is noted that an unworked *M* IX tree becomes dwarfed and precocious though no graft union is present.

Theory of Coacervation

AN interesting paper by Dr. Irving Langmuir (*J. Chem. Phys.*, 6, 873; 1938) deals with a new theory of coacervation. Unipolar coacervation results from micelles of similar charge, and bipolar coacervation from micelles of unlike charge. The formation of tactoids from thixotropic sols, of Schiller layers from ferric oxide sols, the separation of tobacco virus solutions and bentonite sols into two liquid layers, and the crystallization of proteins are regarded as being typical of unipolar coacervation, and involve attractive forces. The previous ideas about Coulombic attraction are shown to give an excessive attractive force between micelles and oppositely charged ions which must be compensated by repulsive forces and by the dispersive action of thermal agitation. Long-range van der Waals forces are discarded and a new theory of coacervation, based on the Debye-Hückel theory of the osmotic pressure of electrolytes, is developed mathematically. The limitations of the Debye-Hückel theory are discussed. A theory of relaxation of birefringence has also been worked out in which dilute thixotropic sols of bentonite are assumed to be arranged normally in a cubic lattice, and temporary shear in the liquid orients the micelles and produces birefringence although the lattice remains cubic. In bipolar coacervation, the electric fields and the charges on the micelles increase as the molecular concentration increases until at a certain concentration the field attains a value so high as to cause increased hydration which keeps the micelles apart and confers stability to the coacervate.

Wind Speed by Kites

THE considerable altitudes to which Japanese humming kites can ascend without their notes becoming inaudible on the ground seemed to provide a convenient method of determining the speed of the wind at these altitudes, and S. Suzuki and Z. Miduno of the University of Hukuoka have investigated the effects of wind speed on the pitch and amplitude of the stretched ribbon which hums (*Proc. Physico-Math. Soc. Japan*, Nov. 1938). The ribbon used was of metal about 80 cm. long, 0·3 cm. broad and 0·011 cm. thick stretched horizontally in a wind tunnel and its motion determined by light reflected from a small mirror. The wind stream was parallel to the breadth of the ribbon. The oscillations are principally torsional and their fundamental frequency is that of the transverse oscillation, a thin round wire of the same length and mass per unit length under a stretching force exceeding that used by $16nb^3/a$, where n is the rigidity of the material of the ribbon, a half the breadth and b half the thickness. The speed of the wind has very little effect on the pitch of the fundamental note but a considerable effect on the amplitude and on those of the harmonics, and it is these effects which the authors hope to use as means of measuring the wind speed.

Corpuscular Eclipse of October 1, 1940

A RECENT paper (*Mon. Not. Roy. Astro. Soc.*, 98, 9, Supplementary Number, Oct. 1938) gives a description of the application of the occultation machine in the Nautical Almanac Office to the prediction of the corpuscular eclipse. The velocity of the corpuscles emitted from the sun is about 1,000 miles a second and large 'aberration' terms are necessarily introduced into the positions of the sun and moon, the values corresponding to corrections representing 'light-times' of 1·0706 days and 221 seconds for the sun and moon respectively. There is some doubt regarding the manner in which the corpuscles leave the sun. If they are expelled radially it is obvious that the sun must be treated as a point-source, but this assumption does not accord with observation. There are no reliable data, however, to show the most suitable diameter to adopt, though it is certain that it must be considerably less than that of the visual sun, and about the order of one fourth of its apparent diameter. A table supplies the corrected times of beginning and end of the corpuscular eclipse at all points in the network covering South Africa. A map shows the track of the corpuscular eclipse for a height of 300 km.—the height of the upper ionized layer of the atmosphere, from which wireless waves are reflected. There is very little difference in the times of beginning and ending between the 300 km. height and the 100 km. height at which the lower ionized layer exists, except, as might be expected, near the end and edges of the track. In addition to the assumed speed of 1,000 miles a second, Besselian elements have been computed and predictions made for a speed of 1,100 miles a second. The general effect of this increased speed of propagation is to displace the track towards the south and west and the times are later by 10–16 minutes. It is hoped that much useful information will be derived from this corpuscular eclipse. The paper is communicated by the Astronomer Royal.

Polar Aurora and Night-Sky Light

PROF. H. H. PLASKETT has recently published a paper with the above title (*Occas. Notes, Roy. Astro. Soc.*, No. 2, Oct. 1938), in which he gives a summary of the methods for studying these two phenomena. It may be mentioned that the object of these *Occasional Notes* is to provide a fairly simple and non-technical description of various astronomical matters which can be followed by the general astronomical reader, and for this reason many non-astronomers will find the paper very interesting. Dufay's night-sky photometer, described very briefly in the paper, has been found the most satisfactory for the study of the night-sky light, and Brunner has accomplished some valuable work by means of this apparatus. He has found that the increase of surface brightness with zenith distance to a maximum at 70° can be represented if two main sources are postulated—a low-lying layer at a height of 5 km. which contributes more than half the surface brightness, and upper layers at heights of 1,000 km. or more, the contribution of the latter being variable with time: on the average it is the equivalent of one first magnitude star every 66 square degrees. Brunner attributes the low-lying component to diffuse reflection by the lower atmosphere of light already reflected off the surface of the earth. The origin of the upper component and also of the aurora is discussed and a brief reference is made to the various theories which have proved acceptable for a time but which are open to serious objections. Hulburt and Maris have recently abandoned the solar-stream hypothesis, and they believe that the charged particles responsible for the aurora are produced in the earth's atmosphere from ionization by the ultra-violet light of the sun. The theory has not, however, been generally accepted, and more research is necessary before it is possible to make any definite pronouncement on the causes of the night-sky light and of the aurora.

Discriminatory Effect of Ultra-violet Rays on Mutation in *Drosophila*

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THE discovery that rearrangements of genes in *Drosophila* produce 'position effects' like the effects of 'gene mutations', and that such rearrangements may be so minute as to be practically indistinguishable cytologically or genetically from gene mutations[1] has raised the question whether there is any essential distinction between so-called gene rearrangements and gene mutations, or whether the latter are to be regarded merely as special cases, at the extreme lower limit of size, of the former. This question, fundamental both to problems of genetics and of the biological action of radiation, has recently become more acute since it has become known that, although gross rearrangements vary in frequency as the 3/2 power of the number of ions produced by X-ray irradiation[2,3,5] (indicating that they commonly involve the reunion of chromosomes broken at two or more separated points by separate ionizations or activations), minute rearrangements, like 'gene mutations', vary directly as the number of the ions[4,5] (indicating that two breaks near together may result from one ionization or activation).

If, now, an agent could be found which discriminated between either gross or minute rearrangements and 'gene mutations', producing the latter but not the former (even when used in sufficient strength and in such circumstances as to have allowed an appreciable number of the gross rearrangements to be formed according to the 3/2 exponential rule, provided the points of genetic change had really represented effective breakages), then there would be *prima facie* evidence that the breakages giving rise to *these* rearrangements were in some way different from the changes resulting in the gene mutations. After some earlier negative results it had been convincingly demonstrated by Altenburg[6] (1930, 1931) and corroborated by Reuss[7], who obtained more intense effects (the results of Geigy[8] and of Promptoff[9] in 1931 and 1932, concerning this question were rather inconclusive), that ultra-violet light produces gene mutations in *Drosophila*. Shortly after his first positive results on ultra-violet gene mutations, Altenburg (1931, 1936) made some rather extensive tests for gross rearrangements (both inversions and translocations) but did not obtain any[6]. These results were, however, admittedly insufficient for a decision, since part of the treatments were of cells (embryonic) in which the chromosome conformation is unfavourable to the reunion of widely separated breakage points, even when produced by X-rays, and since the rest involved treatments which, in the light of our exponential rule, we now know to have been of too low a strength as judged by the frequency of the gene mutations produced, to have allowed an appreciable production of gross rearrangements (in view of the latter's resulting from two independent ionizations or activations).

Not long after Altenburg's findings, it was proved by Noethling and Stubbe[10] (1934) that ultra-violet light produces gene mutations in pollen of *Antirrhinum*; Stadler and Sprague[11] soon afterwards (1936) obtained similar results with maize pollen. Stadler and Uber[12] then attacked the problem of the relative effectiveness of ultra-violet in producing gene mutations, gross rearrangements of the translocation type, and other changes in maize pollen. Using a sufficiently strong dose, as shown by the frequency of induced gene mutations, they succeeded in demonstrating that in this material the genetic effect of ultra-violet light is qualitatively different from that of X-rays in that the former produces gene mutations without translocations, or with a far lower frequency than the latter. It has remained necessary, however, to test this question on *Drosophila* also, not only because this organism, standing almost at the opposite pole of the organic world from the plant material, might, *a priori*, present fundamental differences, but also because the known differences in genetic reactions (especially the lack or dearth of 'position effect' in the plants and the apparent occurrence of single-break chromosome changes in them) indicated that the hereditary material might be differently constituted, in that, for example, as Brink[13] had suggested, the genes in the plants might conceivably be grouped in batches having differing connexions between, from those within, the latter.

In the present experiments, adult male *Drosophila* were irradiated with ultra-violet light, since in the mature spermatozoa, with their crowded chromosomes, rearrangements are produced far more readily than in other cells. To allow maximal treatments, they were held immobile by the pressure of the quartz cover glass so as to allow irradiation through their ventral surface, according to Reuss's technique, with modifications, and young 'yellow-white' flies with the minimum of pigmentation were used. To reduce the 'burning' action and so to allow a greater dose of wave-lengths of 280–310 mμ, which both Stubbe and Noethling[14], and Stadler and Uber[12] had found to be genetically very effective, a 2-mm. filter (either Schott and Gen. 'U.G.2', melt 4924, or Chance 'Uviol') cutting off wave-lengths shorter than 280 mμ and most of those longer than 400 mμ was used. The source was a water-cooled capillary mercury arc of the type of Daniels, Farrington and Heidt[15], consuming about 500 watts. After the lethal dose had been determined by experimentation, a dose 50–80 per cent as strong as this was applied to the flies to be bred. Total ultra-violet dose applied was determined by a Weston photronic cell, standardized against oxalic acid-uranyl sulphate solution; it varied from $2{\cdot}0 \times 10^{19}$ to $4{\cdot}0 \times 10^{19}$ quanta with the U.G.2 filter to 3·0–5·5 for the Chance filter, this being given by 20 minutes' exposure at 7 cm. from the source. The lots of flies (of about forty each) were divided at random after treatment, about one third being tested for lethals (representing gene mutations) by the 'ClB' method, and the rest tested for translocation of all major chromosomes, by crosses to females with attached *X*'s and the 'markers' yellow brown

ebony eyeless, followed by back-crosses of the F_1 males to flies of the same stock.

In a preliminary experiment (irradiation of March 15) 165 of the F_1 cultures tested for lethals yielded 4 lethals (2·4 per cent), while 125 tested for translocations yielded none. Irradiations of April 19–21 led to 213 cultures with 7 lethals (3·3 per cent) and 305 cultures, from flies irradiated with half this dose, with no translocations. The later irradiations have given a total of 1,070 ClB cultures with 22 lethals, or 2·1 per cent, and 2,449 cultures tested for translocations, with not one case of the latter. 579 control cultures (not treated) gave only one lethal, and infra-red rays, in semi-lethal dose, gave 1 lethal in 252 F_1 cultures. The latter results show that the great majority of the lethals in the treated series had resulted from the ultra-violet irradiation.

Our tests with X-rays[6] have shown that the above represents a frequency of lethals such as is produced by about 600 r. and that with this dose there are some 0·8 per cent of translocations produced in spermatozoa (more exact tests are in progress). With the above numbers of F_1 cultures tested for translocations, then there would have been some 13 to 26 translocations in all, instead of none, had X-rays of the same gene-mutation-inducing dose been used. The difference between this and the result obtained (0) is statistically significant. Moreover, 28 of the ultra-violet lethals, tested for crossing over, showed none to involve gross rearrangements, although the same number of lethals, if it were produced in spermatozoa by X-rays giving the same mutation frequency, would usually include several rearrangements. All in all, then, there can be no question of the difference in the genetic action of ultra-violet and X-rays in *Drosophila*, or of the existence of a difference in the mechanism whereby the 'point changes' leading to gene mutations and gross rearrangements, respectively, are produced.

Spectrometric determination of relative intensities of different spectral regions in the case of the two alternative filters indicated that approximately the same amount of genetic effect was produced by the two filters when the dosage between wave-lengths 280 and 300 mμ was held constant, even though in that case the Chance filter transmitted (during the total time it was used) 50 per cent more of the longer wave-lengths than the U.G.2. If confirmed, this would mean that wave-lengths longer than about 300 mμ were relatively ineffective genetically (cf. Noethling and Stubbe[10,14] and Stadler and Uber[12]). This question is being investigated further.

It will be of especial interest to know whether or not ultra-violet light, as compared with X-rays, discriminates between the production of minute rearrangements and gene mutations. Work on this problem is now in progress.

The assistance of the Scottish Cancer Control Organization in furnishing funds for this investigation is acknowledged with thanks.

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The Mathematical Association

Annual Meeting

THE annual meeting of the Mathematical Association was held at King's College, London, W.C.2, on January 2 and 3. At the business meeting, Mr. W. C. Fletcher was elected president for the ensuing year and officers were elected as follows: *Treasurer:* Mr. K. S. Snell; *Secretaries:* Mr. G. L. Parsons and Mrs. E. M. Williams; *Librarian:* Prof. E. H. Neville; *Editor of the Mathematical Gazette:* Mr. T. A. A. Broadbent. Special reference was made to the work done for the Association by Miss M. Punnett, who retired from the office of secretary after twenty-seven years. Miss Punnett was elected a vice-president of the Association. A revised set of rules, proposed by Prof. E. H. Neville, was carried.

The report of the Council gives the number of members as 1,714 and refers to the activities of the branches. A new branch at Sheffield has recently been formed. Several sub-committees of the Teaching Committee are at present working on different aspects of mathematical teaching, including one on trigonometry and another on mathematics for evening technical students. The report further refers to the recently issued "Second Report on the Teaching of Geometry", to the Library and the Problem Bureau, and to the decision of the Council to recognize approved student societies as junior branches. A student society at Cambridge has already been recognized under this rule.

The presidential address was given by Mr. W. Hope-Jones of Eton College, who chose as his subject "Simplicity and Truthfulness in Arithmetic". His first plea was for 'checkability', and he claimed that a well-done piece of work is easier to check by reading it than by doing it again. He also criticized some current practices such as 'cancelling', undue use of improper fractions, loose wording notation in percentage examples and the 'unitary' method. He claimed that teachers were to blame for these defects, since boys have not enough ingenuity to invent their own bad methods, and he attributed

his own progress in arithmetic to avoidance of dodges for making easy things difficult. Finally, he dealt with tables, with special reference to difference-columns, and gave an instructive comparison of the relative accuracy of different methods of constructing and using these tables. The address was delivered in an extremely witty and amusing style, and was greatly appreciated by the crowded audience.

The next address was by Prof. W. L. Bragg, on "Crystallography". Prof. Bragg first dealt with the symmetry of patterns in two dimensions, and, having explained the division of two-dimensional patterns into cells, proceeded to enumerate the seventeen different types of symmetry, of which illustrations were given. He then considered space lattices in three dimensions and illustrated the fourteen distinct types, which give rise to 230 different varieties of three-dimensional symmetry. He illustrated this by reference to one particular group, namely, the space-groups of the orthorhombic lattice. Prof. Bragg concluded by explaining how these types of symmetry enter into crystal structure so as to give rise to the thirty-two classes of crystal symmetry. The lecture was illustrated by slides and was keenly followed by a good audience.

The proceedings of the second day were opened by Mr. A. Buxton, who spoke on "The Teaching of Applied Mathematics in Technical Colleges". He used the term 'applied' in its widest sense, as the students in such institutions require to learn mathematics in order to apply it to engineering, physical chemistry, optics, architecture, etc. The limited previous experience of these pupils and the small amount of time at their disposal (evening students outnumber day students by three to one), means inevitably that the content of the syllabus has to be reduced to a minimum. 'Short cuts' have to be developed wherever possible and formal proofs to a large extent have to be omitted. Mechanics has proved especially difficult, but Mr. Buxton showed how some of the difficulties can be overcome by the use of accurate graphical work and concluded with an interesting example of the use of a velocity diagram to find the velocity of a carried point.

Mr. H. W. Newton gave an interesting illustrated lecture on "Greenwich Observatory: some Aspects of its Work". He showed by a short historical sketch how the work of the Observatory has been mainly concerned with positional astronomy in accordance with its original charter and referred to the discovery of aberration as a result of this work. Illustrations were shown of the older buildings and instruments and also of the instruments now in use, especially those used in the determination of time by observing the transit of a star, a process which Mr. Newton described in some detail, and in stellar photography. He concluded his lecture by a reference to some of the work which has been done in observing the surface of the sun and in photographing, in hydrogen light, bright eruptions and other markings upon it.

The principal speakers in the discussion on the "Second Report on the Teaching of Geometry" were Mr. A. W. Siddons, Miss W. M. Lehfeldt (deputizing for Miss M. A. Hooke) and Mr. H. Beardwood. In the main, all these speakers commended the report. Mr. Siddons referred to some points with regard to the use of small letters to denote angles and to the method of distinguishing the cases of congruence. He also recommended that the idea of similarity should be introduced at an early stage. Miss Lehfeldt emphasized the necessity of a knowledge of geometrical facts rather than their proofs, and also referred to the need for partnership between the teacher and the class in 'rider' work. She referred to the section on the relation between geometry and geography, a region in which valuable chances of illustrating mathematical principles are frequently missed. Mr. Beardwood criticized the omission of any reference to the inter-relation of geometry and trigonometry, and the absence of any special suggestions for the geometry desirable for very weak pupils. In the subsequent discussion, valuable points were raised by Messrs. Kenworthy-Browne, Inman, Sheppard, Hope-Jones, Kearney, Snell, Roebuck, Broadbent and W. C. Fletcher.

The afternoon session was opened by Mr. W. L. Ferrar, who spoke on "Algebra in the Higher School Certificate". He stated that the ideas of general convergence of series and sequences are, in his opinion, introduced too early in the course, a procedure which leads to an excessive reliance on the 'ratio test'. The principal use of convergence at this stage should be in connexion with the series for $\log(1+x)$, e^x and $(1+x)^n$, and for these series *ad hoc* methods involving integrals should be used. He next referred to defects in the understanding of the logic of algebra, as, for example, the distinction between theorem and converse, and muddled ideas on the nature of proof by induction, a process in which the fundamental principles are easily obscured by the manipulations involved. He also dealt with some points concerning difference equations. The present situation in regard to higher algebra is, he said, becoming difficult, especially for the examiner. The casting out of some of the old items in the syllabus and the introduction of some new ones have reduced the syllabus to a collection of odd and unrelated scraps. He suggested the formation of a committee to put forward the views of the Association in this matter.

At the final meeting, Lord Stamp spoke to a large and interested audience on "Education and the Statistical Method in Business, with Special Reference to Railway Statistics". Lord Stamp considers that education can do more to prepare the student for business life, and gave a valuable list of topics of a statistical nature which might with advantage be introduced in the ordinary teaching of mathematics. He first referred to averages—with their adjuncts the standard deviation, the mode, the median and the quartiles—and to moving averages, in regard to which he made some useful suggestions about the choice of a scale, and to percentages, urging the use of examples from social and economic sources. He next considered various graphical methods to which pupils might be introduced, with some cautions as to possible errors. The ideas involved in the use of samples and of index numbers might also be introduced and explained. He referred also to price levels, correlation coefficients, graphical methods for eliminating short-period fluctuations, and units of cost and performance. A number of interesting examples were quoted in connexion with some of the above items, such as weighted averages and operating ratios. Lord Stamp concluded with some remarks on the difficulty of choosing a useful unit in which some types of performance could be measured, and illustrated his remarks by a further reference to railway problems.

A fuller account of the proceedings of the meeting will appear in forthcoming issues of the *Mathematical Gazette*.

The Physical Society

Annual Exhibition

YEAR by year the Physical Society holds an exhibition of scientific instruments and apparatus, which has now grown so that this year—the twenty-ninth—111 individuals and firms describe their exhibits in a catalogue of more than two hundred pages. The exhibition is divided into two sections, one a Trade Section where various physical instruments may be inspected, and the other a Research and Experimental Section.

The Trade Section is of great value to the prospective purchaser of physical apparatus, since it gives him the opportunity of comparing alternative makes of instrument at one time. This aim would be facilitated by a better index to the catalogue so that, for example, gas-analysis apparatus and carbon dioxide and oxygen meters came under a common heading. One reflection that must strike the visitor to this assemblage of instruments is the immense variety of uses to which electronic devices are now put in commercial and industrial instruments. British industry also responds quite rapidly to new needs imposed by legislation or by the political situation, and A.R.P. is mentioned in several of the catalogue descriptions. The Factories Act of 1937 has led to a spurt in the output of photometric equipment, much of which utilizes photo-electric cells, thereby obtaining rapid response and the advantage of a wide range; one instrument can read from extremely low values, of the order of 0·001, up to 100 ft.-candles. The photo-electric cell finds application also in temperature control. For this purpose, the pointer of the instrument which indicates the temperature to be controlled casts a shadow on a selenium cell, and any deviation from its pre-selected position operates the cell and hence a control to restore the temperature to its original value.

The report of the Ministry of Transport Committee on traffic noise is doubtless a contributory factor to the activity shown in the production of noise-meters and other acoustic instruments, of which many were on view. The high-vacuum pump has long been an important tool both in the physical laboratory and in technical processes, and it was interesting to see a new diffusion pump in which the oil or mercury had been replaced by an organic fluid of very low vapour pressure, and means had been provided for continuous self-purification of this fluid, thus avoiding the accumulation of condensable vapours in the pump system, and permitting the attainment of very high vacua, whatever the composition of the gases being removed.

Turning attention now to the Research Section, it is impossible to deal in detail with all the exhibits, which range over almost the whole field of pure and applied physics. Some of the best, such as the colorimetric equipment of Dr. W. D. Wright and Mr. H. V. Walters, and the investigations on dielectrics by the staff of the British Electrical and Allied Industries Research Association, were of rather specialist character. An exhibit of more general interest was provided by the Physics Department of the National Physical Laboratory, and illustrated forcibly the great variety of problems dealt with at the Laboratory. The acoustics exhibit included the analysis of noise, where visitors could see the intensities of the various frequency components in a complex sound as a linear spectrum in a cathode ray oscillograph, as well as the wave-form of the same sound in a neighbouring cathode ray tube; models also demonstrated how the transmission of noises in a building can be diminished. Other exhibits showed the work on radium and X-rays, whilst a set of illuminated models of crystal lattices was attractive, even if it conveyed little new information.

Many visitors were attracted by the exhibit organized by the Scientific Computing Service, Ltd., where in addition to a display of calculating machines, there was a new 135-character typewriter, and an interesting survey of the whole history of the production of a mathematical table, from the first calculations to the final printing. Pure mechanics is somewhat out of fashion, but Messrs. W. and T. Avery, Ltd., showed that it still has points of interest, in an exhibit which showed various little-known statical principles which find application in weighing mechanisms. Messrs. H. A. Boot and A. H. Knight showed a small model of the electrostatic generator used in nuclear research by Prof. van de Graaff, which operates by collecting charges from a moving insulated belt and allowing these to accumulate within a metal sphere. The generator shown could furnish a current of 30 μa., the maximum voltage being 250,000.

Two ingenious experiments for the school laboratory were shown by Mr. W. O. Clarke, in one of which Planck's constant is determined with apparatus no more complicated than a commercial photometer and an incandescent lamp with electrical measuring instruments, and the other enables the specific heat of air to be measured by using a hot-air blower as the basis of a continuous-flow calorimeter.

Among the many novelties shown by the Research Laboratories of the General Electric Co., Ltd., was an apparatus for measuring the mean strength of a magnetic field by amplifying the alternating E.M.F. obtained when a small coil is rotated in the field. They also demonstrated a method by which the intensity of the light from a photo-flash lamp (which reaches its maximum in only 0·05 sec. from ignition) can be studied in detail as a function of time.

In a demonstration by Drs. E. E. Widdowson and S. J. Gregg, multi-molecular layers of barium stearate were being built up by the successive deposition of mono-molecular layers. A striking feature is the vivid colours, changing rapidly with the number of layers, which are seen when the multi-molecular film is viewed by polarized light. The behaviour of lamp filaments and their mountings under vibration must be important to the designer and manufacturer, and many visitors found a stroboscopic picture of this behaviour to be both attractive and informative. This was one of several items included in the exhibit of the Research Laboratories of the British Thomson-Houston Co., Ltd. Finally, many lecturers will be grateful for the simple method demonstrated by Prof. J. D. Bernal, whereby the relation between the Laue diagram and the Bragg reflection patterns can be shown visually.

Exhibition of Scottish Art

VISITORS to the present exhibition of Scottish painting, sculpture, furniture and other work of art, on loan from various public and private sources, at the Royal Academy, London, are likely to feel the force of the complaint that Scotland was not adequately represented in the exhibition of British art held some winters ago. Certainly men of science should find much there to interest them in the healthy realism displayed in many fields.

The exhibits, which exclude the work of living artists, range mainly over the seventeenth, eighteenth and nineteenth centuries, and dealing largely with Scottish subjects, clearly reflect national character, customs and influencing geographical environment. There are portraits of a small number of men of science, including Murray's "Edmond Halley" (21), Raeburn's "Professor John Robison" (84), an early secretary of the Royal Society, Shannan's "Lord Kelvin" (395) shown bare-headed in academic robes, and Walton's "J. G. Bartholomew, LL.D." (538) in doctor's robes with hand on globe. But amid the vast array of portraits by Raeburn, Ramsay and others, attention may well be directed, also, to Raeburn's magnificent rendering of "Sir Walter Scott" (83) sitting outside Hermitage Castle with the mountains of Liddesdale in the background, to Macnee's huge canvas "The Rev. Ralph Wardlaw, D.D." (196), outstanding as a study in force of character and ministerial type, and to the near-by fine portrayal of Macnee's own daughter "Lady in Grey" (199). In group portraiture those who look for expression of what is typical in national culture will appreciate Lorimer's "Ordination of Elders in a Scottish Kirk" (545).

Landscape, which notwithstanding its prominence in literature, arose in art rather later in Scotland than in England, is quite well represented in the collection, and shows an interesting association with group portraiture. Of this association there are two outstanding examples: one, Guthrie's large canvas "A Highland Funeral" (513), where the assembly appears in snow-clad moorland outside a stone cottage; the other, the same painter's "Schoolmates" (525), wherein two girls and a boy, of quite striking physical beauty, are wending their way to school in a late autumn landscape. William McTaggart, perhaps the most original of the Scottish landscape painters, has almost a gallery to himself: "Away o'er the Sea", "The Storm", "The Wind in the Grass", "The Wave", "Blithe October", "April Snow" and "Spring" being a few of his contributions. A characteristic of this artist is his habit of putting a group of children in the foreground of his rural or seashore pictures, and, though in some cases the figures are not very successfully delineated as elements in the landscape, in others the effect is admirable. Thus in "Spring" (384), the blue range of hills in the background, the cottage with trees in the middle distance, the sheep, and the children plucking wild flowers in front, are all in perfect relationship, constituting a typical scene of the Lowlands of Scotland. In this characteristic, McTaggart shows himself in spirit a true Wordsworthian. David Farquharson's "River Road, Strathdon" (295) is a summer scene showing shepherd and flock and pouring rain over a distant range of mountains, whilst Joseph Farquharson's "Stormy Blast" (296), one of this painter's famous snow scenes, is a fine piece of impressionism, illustrating the smothering effect of snow upon a moorland flock of sheep. The omission of a few pictures of the type of "Stormy Blast" from any exhibition of Scottish landscape would be unthinkable, for the imagery of snow is somewhat obtrusive in the literature of Scotland and deeply rooted in one's sense of the wild beauty and romantic history of that rugged northern land.

In pure landscape, however, at any rate as regards Scottish scenery, the masterpieces are McCulloch's famous "Glencoe" (177) and Peter Graham's "Wandering Shadows" (238). In "Glencoe" there is massiveness both of mountains and of mountainous cumulo-nimbus clouds so closely interlocked that in one place the painter rightly leaves the spectators in doubt to which element a dark rugged outline belongs. Pine trees stand at intervals down the glen, there are stags in the foreground, and in the left-hand corner, half hidden in a gloomy ravine, lies a sullen tarn. In "Wandering Shadows" the painter of the "mountain and the flood" has left us a superb piece of chiaroscuro. The nearer mountain flank is gloriously lit in contrast with the farther range, which is steeped in intense blue-black shadow. Mists are coursing the mountain sides so realistically that one almost sees them driving—a sure indication of good work. In the foreground a man is fishing in the torrent, and there are sheep grazing amid lichen-crusted boulders showing just the right amount of detail.

In sculpture, mention may be made of a "Symbol Stone" from Orkney with a design the meaning of which is lost, but known to date from Early Christian times, and also of a kid standing on a rock—reflecting a Highland background. In the vestibule, the visitor is greeted, symbolically, by a statue of John Knox with Bible in hand.

L. C. W. BONACINA.

Science News a Century Ago

The Institution of Civil Engineers

AT the annual general meeting of the Institution of Civil Engineers held on January 15, 1839, the president, James Walker, being in the chair, the report for the year was presented. At this time no fewer than nine members of the Council were fellows of the Royal Society, J. Walker, W. Cubitt, Bryan Donkin, Joshua Field, H. R. Palmer, I. K. Brunel, Joseph Locke, George Lowe and John Macneill. One of the problems the Council had considered was that of qualification for membership. "The objects of the civil engineer," the Council said, "were defined by charter and in guiding them in their task they had adhered closely to the two following conditions: (1) that the party should have been regularly educated as a civil engineer according to the usual routine of pupilage, and had had subsequent employment for at least five years in responsible positions, resident or otherwise, or (2) that he should have practised on his account in the profession of civil engineer for five years and have acquired considerable eminence therein. In earlier days the force of genius alone was sufficient to place the individual in that position of professorial eminence which commenced with a Brindley and a Smeaton, and was in our own time exemplified in a Rennie and a Telford. To such, of

which there are many illustrious examples still living, the second condition was strictly applicable."

The Interior of the Earth

AT a meeting of the Royal Society held on January 17, 1839, W. Hopkins read his second paper on the state of the interior of the earth, entitled "The Phenomena of Precession and Nutation, assuming the Fluidity of the Interior of the Earth". For the purpose of his investigation Hopkins assumed the solid shell of the earth to be bounded by a determinate inner spheroidal surface of which the ellipticity is equal to that of the outer surface and the shell and fluid to be homogeneous and of equal density. Having given the results of his inquiries as affecting precession, and lunar and solar rotation he said that "the pole of the earth would have a small circular motion, depending entirely on the internal fluidity. The radius of the circle thus described would be greatest when the thickness of the shell should be least; but the inequality thus produced would not, for the smallest thickness of the shell, exceed a quantity of the same order as the polar nutation, and for any but the most inconsiderable thickness of the shell, would be entirely inappreciable to observation."

English Medical Society in Paris

THE *Lancet* of January 20, 1839, contains the following information: "An English medical society has recently been established in Paris and already includes on its list between 90 and 100 members. At one of the last meetings Sir R. Chermside was elected president and J. Godfrey, Esq., vice-president for the present year. The Society holds weekly meetings at which papers are read upon medical subjects and discussions take place in the *English language*. These meetings are peculiarly interesting, as medical men from London, Edinburgh, Dublin and different parts of America join in the proceedings, as well as some of the 'externes' and 'internes' of the Parisian hospitals. The Society has established a reading room for the English and French periodicals, and the nucleus of a permanent library is already in existence."

Geodetical Work at the Cape of Good Hope

IN his "Autobiography", under the year 1839, Airy wrote, "I had much work in connection with the Cape of Good Hope Observatory, chiefly relating to instrumental equipment and to the geodetical work. As it was considered advisable that any base measured in the Cape Colony should be measured with compensation bars, I applied to Major Jervis for the loan of those belonging to the East Indian Survey, but he positively refused to lend them. On Jan. 20th I applied to Col. Colby for the compensation bars of the British Survey, and he immediately assented to lending them. Col. Colby had suggested to the Ordnance Department that Capt. Henderson and several sappers should be sent to use the measuring bars and it was so arranged. It still appeared desirable to have the command of some soldiers from the Garrison of Cape Town, and this matter was soon arranged with the Military authorities by the Admiralty."

The geodetical work at the Cape included the remeasurement and extension of Lacaille's arc, and it was carried out by Sir Thomas Maclear, the Astronomer Royal at the Cape, the results being published in 1866, edited by Airy.

Societies and Academies

London

Royal Society (*Proc.* A, **169**, 149–289; 1938).

C. K. INGOLD: Structure of benzene (Bakerian Lecture).

W. F. HILTON: Photography of airscrew sound waves.

D. H. EVERETT and W. F. K. WYNNE-JONES: Dissociation of the ammonium ion and the basic strength of ammonia in water.

H. S. W. MASSEY and R. A. BUCKINGHAM: Low temperature properties of gaseous helium.

J. N. AGAR and F. P. BOWDEN: Kinetics of electrode reactions (1 and 2).

R. G. AICKIN, N. S. BAYLISS and A. L. G. REES: Effect of solvents on the continuous absorption spectrum of bromine.

T. E. ALLIBONE and J. M. MEEK: Development of the spark discharge (2).

S. C. CURRAN, P. I. DEE and V. PETRŽÍLKA: Excitation of γ-radiation in processes of proton capture by light elements.

Paris

Academy of Sciences (*C.R.*, **207**, 1137–1268, Dec. 12, 1938).*

H. BRUCK: Extension of the $1^1P_1 - m^1S_0$ of zinc.

M. PARODI: Spectra of some derivatives of methane in the far infra-red.

L. MONTLAUR: Absorption and fluorescence spectra of pigments from the St. John's wort of the Mediterranean basin (*Hypericum crispum*). The *Hypericum* from Tunis, which often poisons animals, has different pigments from the European *Hypericum*.

J. DEBIESSE: Absorption spectra and chemical constitution of Sauton's liquid cultivated in tubercle bacilli B.C.G.

G. EMSCHWILLER: Production of iodic anhydride by photo-oxidation of organic oxides; photo-oxidation of iodoform and of solid carbon tetraiodide.

H. HULUBEI, MLLE. Y. CAUCHOIS and MME. S. COTELLE: Spectroscopic determination of the atomic number of polonium. The investigation shows that the detection of elements by their X-ray spectra is much more sensitive than was believed; the radiations detected in this case are those to be expected from an element of atomic number 84.

A. CLAUDE: Fluorescent tube-lamps functioning with the usual distribution voltage.

M. BRUTZCUS: A thermochemical constant and its relations with electronic energy values.

R. ENGELAND: A new form of stereo-isomerism and an unknown form of glycocoll: attempt at a theoretical interpretation.

V. AUGER: Two new molybdic acids.

R. CHAUVENET: Combinations of zinc nitrate and of alkaline nitrates.

A. MORETTE: The system iodine-vanadium: vanadium di-iode and tri-iodide.

G. COURTOIS: Preparation of anhydrous sodium sulphide.

C. DUFRAISSE and M. GERMAN: Study of the mechanism of dry extinction by dusts; nitrate, chlorate, perchlorate of potassium and other bodies which support combustion as extinguishers of flames.

*Continued from page 39.

P. GRAMMATICAKIS : Action of organomagnesium mixtures on the benzylimines : preparation of secondary amines of the type $Ar.(R)CH.NH.CH_2.C_6H_5$.

D. DUVEEN and A. WILLEMART : Synthesis of tetraphenyl-2.6.10.12*bis*-(diphenyl)-9.11-naphthacene and its photo-oxide.

M. TUOT : Interpretation of secondary reactions observed in the course of the condensation by organomagnesium of ketones and of esters of the aliphatic series : theory.

MME. R. DUBERTRET, L. DONCIEUX, H. VAUTRIN and L. DUBERTRET : The nummulitic of the eastern slope of the Anti-Libanon (region of Damascus, Syria).

MME. A. VASSY and E. VASSY : Daily variations of the mean temperature of the atmospheric ozone.

G. LEMÉE : Post-glacial forest history in Lower Normandy after pollen analysis of the peat-bogs.

J. MOTTE : Evolution of the nuclei of the internodal cells of *Chara fœtida*.

MME. I. MICHALSKA and F.-X. SKUPIEŃSKI : Ecological researches on *Polysphondylium pallidum* Olive, *Polysphondylium violaceum* Bref., *Dictyostelium mucoroides* Bref.

MLLE. J. MANUEL : Formation of the ascus of *Nematospora Coryli*, after a sexual phenomenon.

P. RIOU and G. DELORME : Distribution of manganese and of iron in the ashes and elms of the Province of Quebec.

R. ULRICH : Variations of the reactions to superficial lesions as a function of their surface (fruits of *Iris pallida* Lam.).

V. VINCENT and P. BOISCHOT : Nature and composition of the organic matter of the phosphates of North Africa : the phosphate of Gafsa.

J. GEORGEVITCH : *Sphæractinomyxon danicæ* n.sp., an actinomyxidian parasitic on an oligochæte of Lake Ochrida.

RAYMOND-HAMET : Major hypotensor and sympathetolitic effects of hydrocinchonidine.

MLLE. P. BERTHIER : Coefficient of magnetization and electric sign of solutions of hæmatin and of acethæmin.

B. LUYET and G. THOENNES : Revival of muscle fibres vitrified in liquid air.

M. RANGIER and P. DE TRAVERSE : Mode of formation and constitution of urinary scatole red.

G. RAMON : Some methods for the rapid and intensive production of diphtheria and tetanus antitoxins in the horse.

A. SARTORY, J. MEYER and D. SCHMUTZ : Conditions favouring bacterial growth by preliminary introduction of vitamins B_1 and B_2 combined and in varied doses, into the culture medium.

J. RÉGNIER and MLLE. S. LAMBIN : Study of microbial growth as a function of the quantity of nutritive substance in culture media.

J. CHAUSSIN and L. LESCŒUR : Study of the variations of phthalein and formol acidities of urine during 24 hours of eight diabetics.

Sydney

Royal Society of New South Wales (*J. and Proc.*, 72 ; 1937–38).

S. B. COHEN and F. M. QUODLING : An X-ray examination of chillagite. From oscillation and powder photographs (copper $K\alpha$) chillagite has been found to have cell dimensions in close agreement with those of wulfenite and stolzite and the same number of molecules per cell (4). Chillagite is regarded as a mixed crystal of these two substances, not as a distinct mineral species.

J. G. CHURCHWARD : Studies on physiological specialization of the organisms causing bunt in wheat, and the genetics of resistance to this and certain other wheat diseases. (2) Genetical studies. In a wheat cross, Federation × Hope, studies were made in the field and greenhouse on the inheritance of resistance to bunt, to flagsmut, to two races of stem rust, and certain morphological characters. In addition to the single factor for resistance to bunt, there are several modifying factors acting in this cross. With two exceptions, the inheritance of the remaining characters is explained by simple Mendelian hypotheses.

S. W. CAREY and W. R. BROWNE : Review of the carboniferous stratigraphy, tectonics and palæogeography of New South Wales and Queensland. A scheme of subdivision is proposed for the Lower and Middle Carboniferous of New South Wales, embodying recognition of the fact that freshwater and marine sedimentation proceeded simultaneously in Viséan time. Many, if not all, the known occurrences fit into this scheme. Correlations are also instituted with Queensland. The earth-movements which determined loci of sedimentation and affected the sediments after deposition are enumerated—the late Devonian Kanimbla, the epi-Burindi Drummond and the late Permian Hunter-Bowen orogenies, with minor vertical movements at the close of Lower Burindi and Upper Kuttung times.

ADOLPH BOLLIGER and A. L. CARRODUS : Changes in and around the pouch in *Trichosurus vulpecula*, as occurring naturally and as the result of the administration of œstrone. The sexually immature Australian opossum (*Trichosurus vulpecula*) shows no pigmentation in its undeveloped pouch, and the hair on its ventral aspect is usually white. Injections of œstrone bring on development of the pouch, mammary glands become evident, and the nipples undergo hypertrophy. Simultaneously a pigment is secreted within the pouch and forms a dark brown deposit, while the hairs within the pouch as well as those around it become stained from a yellow to a dark golden brown. Similar changes were observed to occur under natural conditions, and they are considered to be connected with the sex life of the animal.

Washington, D.C.

National Academy of Sciences (*Proc.*, 24, 497–523, Nov. 15, 1938).

R. A. BRINK and D. C. COOPER : Partial self-incompatibility in *Medicago sativa*. Pollen is less efficient in self-pollinations than in cross-pollinations, while ovules containing inbred embryos show a greater tendency to collapse than those from cross-fertilization.

J. G. CARLSON : Mitotic behaviour of induced chromosomal fragments lacking spindle attachments in the neuroblasts of the grasshopper.

C. STOCK : A titanothere from the type Sespe of California.

BARBARA S. BURKS : Autosomal linkage in man : the recombination ratio between congenital tooth defigiency and hair colour.

R. COURANT : Remarks on Plateau's and Douglas's problem.

Forthcoming Events

[*Meetings marked with an asterisk are open to the public.*]

Monday, January 16

UNIVERSITY OF LEEDS, at 5.15.—Dr. J. Hammond, F.R.S.: "Fertility and Growth in Domestic Animals" (Clive Behrens Lectures. Succeeding lectures on January 30, February 20 and 27 and March 13).*

Tuesday, January 17

EUGENICS SOCIETY (at the Royal Society), at 5.15.—Dr. Felix Tietze: "Eugenic Measures in the Third Reich".*

UNIVERSITY COLLEGE, LONDON, at 5.30.—Sir Ambrose Fleming, F.R.S.: "History of the Thermionic Valve at University College".*

ILLUMINATING ENGINEERING SOCIETY, at 7.—Discussion on "Lighting in Relation to Air Raid Precautions".

Wednesday, January 18

ROYAL MICROSCOPICAL SOCIETY, at 5.30.—J. E. Barnard, F.R.S.: "Towards the Smallest Living Things" (Presidential Address).

ROYAL METEOROLOGICAL SOCIETY, at 7.30.—Dr. B. A. Keen, F.R.S.: "What Happens to the Rain?"

ROYAL SOCIETY OF ARTS, at 8.15.—H. L. Kirke: "Recent Progress in Television".

Thursday, January 19

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY (ROYAL SCHOOL OF MINES), at 5.30.—Dr. J. Hammond, F.R.S.: "Animal Breeding" (succeeding lectures on January 26 and February 2 and 9).*

Friday, January 20

ROYAL INSTITUTION, at 9.—Dr. Fraser Darling: "North Rona: a North Atlantic Island".

Appointments Vacant

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:

LECTURER IN CHEMISTRY at the Kingston-upon-Thames Technical College—The Principal (January 14).

CHEMISTS at the Royal Gunpowder Factory, Waltham Abbey or the Royal Ordnance Factory, Irvine—The Under-Secretary of State (C.5), War Office, London, S.W.1 (January 20).

ASSISTANT CIVIL ENGINEER at the Royal Ordnance Factory, Bishopton, Renfrewshire—The Superintendent, Royal Gunpowder Factory, Waltham Abbey (January 20).

UNIVERSITY READER IN METEOROLOGY in the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, W.C.1 (January 20).

ASSISTANTS (grade III) in the Meteorological Office—The Under-Secretary of State, S.2 B. (Met.), Air Ministry, Adastral House, Kingsway, W.C.2 (January 31).

LECTURER IN BIOLOGY in the Central Technical College, Suffolk Street, Birmingham, 1—The Chief Education Officer (January 31).

LECTURER IN MINING in the University of Sheffield—The Registrar (February 4).

LECTURER IN BIOCHEMISTRY in the Otago University Medical School—The High Commissioner for New Zealand, 415 Strand, W.C.2 (March 22).

LECTURER IN ENGINEERING in the Swansea Technical College—The Director of Education, Education Department, Guildhall, Swansea.

Reports and other Publications

(not included in the monthly Books Supplement)

Great Britain and Ireland

Memoirs of the British Astronomical Association. Vol. 34, Part 1: Who's Who in the Moon; Notes on the Names of all Lunar Formations adopted in 1935 by the International Astronomical Union. Pp. 130+2 plates. (London: British Astronomical Association.) 4s. 6d. [1412

Department of Scientific and Industrial Research. Forest Products Research Records, No. 27 (Mycology Series, No. 3): Decay of Timber and its Prevention. By W. P. K. Findlay. Pp. ii+15+5 plates. (London: H.M. Stationery Office.) 6d. net. [1412

Publications of the International Tin Research and Development Council. No. 82: Electrodeposition of Tin from Alkaline Solutions. By S. Baier and R. M. Angles. Pp. ii+30. Free. No. 83: The Electrodeposition of Tin from Acid Sulphate Solutions, II. By A. W. Hothersall and W. N. Bradshaw. Pp. ii+18. Free. (Greenford: International Tin Research and Development Council.) [1412

Friends of the Hebrew University of Jerusalem. Annual Report, 1937–8. Pp. 28. (London: Friends of the Hebrew University of Jerusalem.) [1512

Association of Special Libraries and Information Bureaux. Report of Proceedings of the Fifteenth Conference, 1938. Pp. 135. (London: ASLIB.) 5s. [1512

Royal Technical College, Glasgow. Annual Report on the One Hundred and Forty-second Session. Pp. 93. (Glasgow: Royal Technical College). [1512

British Association for the Advancement of Science. Norman Lockyer Lecture, 1938: The Atmospheres of the Planets. By Dr. H. Spencer Jones. Pp. 14. (London: British Association.) 1s. [1512

Royal Horticultural Society. Lily Year-Book, 1938. (No. 7.) Pp. iv+181+vii+25 plates. (London: Royal Horticultural Society.) 5s. [1512

Medical Research Council. Special Report Series, No. 232: Medical Uses of Radium; Summary of Reports from Research Centres for 1937. Pp. 48+2 plates. (London: H.M. Stationery Office.) 1s. net. [1512

Roinn Talmhaidheachta (Department of Agriculture): Brainse Iascaigh (Fisheries Branch). Report on the Sea and Inland Fisheries for the Year 1937. Pp. 35. 9d. Statistics of Salmon, Sea Trout and Eels captured during each of the Years 1937, 1935, 1933, 1931, 1929, 1927. Pp. 19. 4d. (Dublin: Stationery Office.) [1512

Science Museum: Board of Education. Hand-List of Short Titles of Current Periodicals in the Science Library. Part 1: Alphabetical. Edited by Dr. S. C. Bradford. Fifth edition. Pp. 262. (London: H.M. Stationery Office.) 9s. net. [1512

Other Countries

League of Nations: Advisory Committee on Social Questions. The Placing of Children in Families. (Official No.: C.260.M.155.1938. IV). Vol. 1: Fundamental Concepts, Historical Development, Characteristic Features in Differing Systems, Principles and Procedures in the Organisation of Services. Pp. xvi+154. 3s. Vol. 2: Various Systems of Placing of Children in Families. Pp. xvi+241. 5s. (Geneva: League of Nations; London: George Allen and Unwin, Ltd.) [1412

Miscellaneous Publications of the Royal Alfred Observatory. No. 19: The Cyclone Season 1935–36 at Mauritius. By N. R. McCurdy. Pp. 5+22 plates. No. 20: The Cyclone Season 1936–37 at Mauritius. By N. R. McCurdy. Pp. 8+29 plates. 60 cents. No. 21: Air Temperature and Humidity Data at Mauritius from Observations taken at the Royal Alfred Observatory 1876–1935. By M. Herchenroder. Pp. 46+15 plates. 1 rupee. Annual Report of the Royal Alfred Observatory for the Year 1937. Pp. 8. (Port Louis: Government Printer.) [1512

Commonwealth of Australia: Bureau of Meteorology. Results of Rainfall Observations made in Victoria. Supplementary Volume, including all Available Annual Rainfall Totals from 1326 Stations for Years 1911–1936 inclusive, and Monthly and Yearly Totals from 239 Representative Stations for the Entire Periods for which Records are available up to the end of 1935, with Maps and Diagrams; also Appendices, presenting "Monthly and Yearly Meteorological Elements and Normals of Melbourne, Ballarat, Bendigo and Geelong", "Table showing Monthly and Annual Normals of Pressure, Temperature and Humidity at Selected Stations in Victoria". Published under the direction of W. S. Watt. Pp. 253+8 plates. Bulletin No. 22: Australian Rainfall in Sunspot Cycles. By E. T. Quayle. Pp. 56. Bulletin No. 23: Australian Rainfall in District Averages. Published under the direction of W. S. Watt. Pp. 56. (Melbourne: Government Printer.) [1512

Annual Report of the Imperial Council of Agricultural Research for 1937–38. Pp. v+168. (Delhi: Manager of Publications.) 12 annas; 1s. [1512

Nigeria. Annual Report on the Geological Survey Department for the Year 1937. Pp. ii+26+7 plates. (Lagos: Government Printer; London: Crown Agents for the Colonies.) 2s. 6d. [1512

Catalogues, etc.

Books on Bibliography, Medicine, Science. (Catalogue No. 17.) Pp. 22. (London: David Low.)

Volpar Contraceptive Preparations: Volpar Gels and Volpar Paste. Pp. 14. (London: The British Drug Houses, Ltd.)

The "Pressovac", a New High Vacuum and Pressure Pump. Pp. 2. (London: W. Edwards and Co.)

Fifty Years, 1889–1939: Calendar for 1939. (Newcastle-on-Tyne: C. A. Parsons and Co., Ltd.)

Mercury in Steel Thermometers, Dial Type. Pp. 4. (London: Negretti and Zambra.)

Catalogue of Books offered at Greatly Reduced Prices. (Catalogue No. 634.) Pp. 68. (London: Francis Edwards, Ltd.)

Calendar for 1939. (Belgrade: Anglo-Yugoslav Review.)

The Wild-Barfield Heat-Treatment Journal. Vol. 3, No. 19, December. Pp. 26–38+v. (London: Wild-Barfield Electric Furnaces, Ltd.)

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